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PREFERENTIAL MANIPULATION IN CHILDREN

BY
JULIA HEIL HEINLEIN

L. C.

A DISSERTATION
SUBMITTED TO THE BOARD OF UNIVERSITY STUDIES OF THE JOHNS HOPKINS UNIVERSITY IN PARTIAL FULFILLMENT OF THE REQUIREMENTS FOR THE DEGREE OF DOCTOR OF PHILOSOPHY
1929

Baltimore, Md.
1930

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PREFERENTIAL MANIPULATION IN CHILDREN*

JULIA HEIL HEINLEIN

From the Psychological Laboratory, Johns Hopkins University

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The purpose of this investigation was to ascertain the preferential use of the hands as manifested by children of pre-school age in motor activities of various types and under varying conditions. Responses to controlled situations, in the form of three tests of hand preference, were studied, as well as responses involved in daily activities of the child's own choice. An attempt was also made to evaluate the tests used as means of determining the extent and degree of preferential handedness. In an earlier investigation (9) the author summarized previous studies in this field and pointed out that there are apparently degrees of preferential handedness rather than the two definite manual types as conventionally designated. This view is likewise advocated by Downey (6), who holds that "the conventional classification of individuals into right-handed and left-handed furnishes very little information about their manual habits," and that "all degrees of unidextrality (the use of one hand in preference to the other) exist."

*This research was completed under a scholarship grant through the Committee on Child Development of the National Research Council.

The subject of handedness is one of intense interest to both layman and scientist. The interest shown by the layman is due to the practical nature of the subject, and numerous are the problems arising therefrom which the scientist is called upon to solve. Contributions to the literature of handedness, however, are not restricted to scientific investigations, but include many popular articles as well. Consequently, although much has been written on the various topics relating to the preferential use of the hands, only a small proportion thereof has real scientific value. An historical survey of the various questions involved in a study of handedness reveals also that considerable diversity exists regarding these questions, not only with reference to theory, but likewise in the conclusions derived from experiments conducted by different investigators.

A much disputed question is that concerning the nature of handedness—whether it is an inherited or an acquired characteristic. Various theories have also been advanced to account for the method by which the trait is inherited, as well as the means through which it is acquired. A review of the various theories of handedness is given in Parsons (13).

Several investigators have made controlled observations regarding the origin and development of handedness in the infant; however, these investigators, also, have failed to agree with reference to conclusions derived from their respective studies. Baldwin (1) and Woolley (16) each maintained, on the basis of results obtained in their respective studies of the origin and development of handedness in an infant, that handedness is something more than an acquired habit, and that its cause must be sought in inherited physiological grounds. Baldwin (1) made a series of controlled observations on his child from the age of 4 months to 10 months, in which he noted the preferential use of the hands in reaching for objects placed before it. He reports a "distinct preference" for the right hand under pressure of muscular effort in the 7th month. The observations made by Woolley confirmed those of Baldwin in this connection. She states that during the 7th month, reaching called out the use of the right hand almost exclusively, though little if any distinction in the

use of the hands could be detected at that time in activities not requiring effort. By the 9th month, Woolley states the child was "evidently right handed." She concluded that "right-handedness is a normal part of physiological development, not a phenomenon explicable by training."

Dearborn (5) conducted a series of observations on a child from the time of its birth until its third birthday, and reports that the use of the right hand gradually became more habitual after the first five months, until at the age of 14 months the right hand was used "much more than the left," despite the fact that "sporadic efforts were made to make the child left-handed and so practically ambidextrous later on."

Watson (15) conducted a number of experiments on infants, consisting of a series of anthropometric measurements, observations of the grasping reflex, measurement of the relative activity of the right and left hand respectively in a given period of time, and observation of the frequency with which each hand was used in reaching for objects. He reports that no steady and uniform handedness was shown in any of these experiments, and concludes that "there is no fixed differentiation of response in either hand until social usage begins to establish handedness."

Gesell (8) maintains that unidextrality is based on inherent constitutional, rather than on cultural factors. The existence of germinal factors, he states, is suggested by the fact that left-handedness is sometimes a familial trait; however, he does not regard this as conclusive, as left-handedness may be a "secondary by-product of a more fundamental familial trait involving vascular or anatomical peculiarities." He cites the case of an infant who showed evidence of left-handedness in the very first day of his life by vigorously sucking his left hand, and who, despite the efforts of his parents to train him during early childhood in the use of the right-hand, nevertheless evidenced the persistence of left hand tendencies upon his entrance into school. Gesell regards this as an evidence of the futility of systematic social conditioning in overcoming inherent left-handedness, and as an indication that the inherence of left-handedness may date from birth.

A number of investigators have concerned themselves with the devising of tests of "native" handedness. Among the various methods used for this purpose are the tests of motor control: dynamometer, which tests strength of grip; tapping, which tests the comparative quickness or rate of movement of the two hands; tracing, which measures accuracy and precision of movement; steadiness, which measures the inhibition of movement of the hands.

Beeley (3) conducted a series of investigations for the purpose of devising a means of detecting native handedness, using the tapping, steadiness, and tracing tests. The subjects were 100 right-handed and 14 left-handed subjects, ranging in age from 6 years to 15 years, and in school grade from the 3rd to the 6th, inclusive. He found that the tapping test in which finger movement was used is superior as a method of diagnosing handedness to the tapping test in which either arm or wrist movement was used; and is also superior to either the steadiness test or the tracing test, for diagnostic purposes. The reasons for the superiority of the tapping test in which finger movement was used, are as follows: first, its diagnoses give a distribution of handedness which correlates more perfectly with the known facts (namely, the child's own statement, corroborated by the teacher); secondly, it reveals a greater difference in dexterity between the two sides of the body.

Jones (12) conducted an extensive investigation on 20,000 individuals, ranging in age from stillborn to centenarian, in order to establish standards for determining born handedness and adopted handedness. He proceeded on the assumption that if an individual either is born with or has acquired unequal potentialities on the two sides of the body, there must be some evidence that will be revealed by the "tape line." With the aid of an instrument termed a brachiometer, he measured the length of the ulna plus, the humerus, circumference of the palm and wrist, circumference of the forearm relaxed and contracted; and of the arm relaxed and contracted. Examination of the data, he states, indicated that "born handedness is revealed by the measures of the bones of the arm, the major arm having the larger bones;

and this evidence is present at birth. Adopted handedness is shown by the muscle swell, the adopted or preferred arm having the higher percentage of muscle swell."

Beeley (3) conducted a series of experiments with the Jones brachiometer on 123 young children in order to determine the reliability of this test for diagnosing born-handedness. On the basis of results obtained, Beeley concludes that, first, the theory upon which the Jones tests are devised is not valid in all cases, as many cases of extreme right-handedness were diagnosed by this test as left-handedness, and conversely; secondly, the distribution of handedness does not agree with the known facts; thirdly, in most children the difference between the length of the bones of the two arms, as shown by these results, is so slight that it would seem to be somewhat hazardous to determine the life habits of a child solely upon such evidence.

Parsons (13) maintains that handedness is caused by eyedness, the favored hand being on the same side of the body as the sighting eye. On the basis of this theory he conducted a series of tests upon 877 grammar school pupils, ascertaining their sighting eye by means of an instrument devised by him termed a manoptoscope. Of the total number of children tested, 608 used the right visual line for sighting. With four exceptions, all the right-eyed persons were right-handed. Two of the four exceptions admitted trouble with the left eye, "the original sighting eye," according to Parsons. However, this almost unbroken relationship between eye and hand is not shown in the case of the left-eyed pupils, numbering 257. Only 32 of this number confessed to being left-handed. Parsons assumes that, in the case of those who were diagnosed as left-handed on the basis of their left-eyedness and who claim nevertheless to be right-handed, their sighting eye had been changed due to ocular troubles, or their handedness had changed due to trouble with the hand. Cuff (4) criticizes this explanation as being theoretical only. On the basis of the results obtained by administering the manoptoscope test to 146 school children, Cuff also maintains that the test as devised by Parsons is unreliable for individual diagnosis.

More recently, attention has been directed to a study of dextrality types other than the two conventional divisions of "right-handed" and "left-handed," cognizance being taken in this study of the tendency to prefer one hand in activities of certain types, and the other hand in activities of other types. Thus, while there are a number of people who use their right hand exclusively for all unimanual acts and for the so-called "business" end of bimanual acts; and a smaller number who use their left hand exclusively; there are many individuals who apparently show divided preference, using the right hand for activities of certain definite types, and the left hand for activities of other types.

Rife (14) has classified individuals into six dextral types on the basis of the following preferential usage: (1) right-handed in unimanual activities and the "business end" of all bimanual activities; (2) right-handed in unimanual activities, and left-handed in the "business end" of all bimanual activities; (3) right-handed in unimanual activities, and in the "business end" of activities of the "first rank," such as golf or batting, but left-handed in the "business end" of the "lesser" acts, such as shoveling and sweeping; (4) left-handed in unimanual activities and in the "business end" of all bimanual activities; (5) left-handed in unimanual activities, and right-handed in the "business end" of all bimanual activities; (6) left-handed in unimanual activities, and in the "business end" of activities of the "first rank," such as golf or batting, but right-handed in the "business end" of the "lesser" acts, such as shoveling and sweeping.

In an extensive study of dextrality types, Downey (6) classified 1500 individuals according to Rife's scheme, with some slight modification. The distribution of dextrality types indicated that, in the group of normal individuals studied, more than half use the left hand wholly or partially for bimanual operations. Interesting sex differences were noted. The percentage of men using the right hand exclusively is 41%; the percentage of women in this dextral group is 36.6%. The majority of the women, namely 51.3%, were right-handed unimanually and in bimanual acts of the "first rank;" whereas 34.6% of the men were in this

group. The percentage of men using the right hand unimanually and the left hand bimanually is 17.3%; the percentage of women, 8.6%. In the group of 257 left-handed studied, 25% of the men and 32% of the women were left-handed in all activities, unimanual and bimanual, the balance of both sexes being right-handed in some or all of the bimanual acts.

Downey investigated with reference to these dextral types for the following: eyedness and handedness; the dominant thumb; the spade foot; handedness types and degree of unidextrality; structural differences and handedness types; handedness types and intelligence; orientation and eyedness; temperament and handedness; handedness and speech defects. Downey indicates that her conclusions with reference to these specific problems are "tentative only;" the main purpose of her investigation being exploratory, to suggest fields for more intensive experimental work.

More recently Downey (7) made a study of the dextrality types exhibited by 49 pre-school children ranging in age from 2 years 9 months to 5 years 10 months, and noted that exactly the same dextrality types were shown by these children as by the adults previously studied, although "a slightly larger per cent of unstable reactions were found in the case of the children." From this she draws an inference that dextrality types are probably inborn, since they are "very different in form, appear with different frequencies in the two sexes, and are manifested very early in life."

In the investigation previously cited (9) in which a study was made of the performance of 60 children in four series of tests of visual-motor coördination, the author found that but 25% of the group consistently made superior scores with a given hand in repeated trials of all four test series; and that the remaining 75% were consistently superior with the right hand in all trials of one or more test series, and with the left hand in the remaining series, or were inconsistent in manual superiority in yearly retrials of one or more test series. This variation of preferential handedness in motor activities of different types is suggestive of "types" of handedness. The author also pointed out in this study the existence of variation in degree of preferential handed-

ness on the part of the subjects who were consistently superior in the performance of a given hand in all four test series. This variation was shown not only with regard to the difference in degree of superiority of the favored hand as evidenced by different individuals in a given yearly test; but also with reference to the tendency on the part of some children to decrease, and of others to increase, in degree of superiority of the favored hand with increase in chronological age.

Experimentation

This study consists of a series of observations on a group of thirty-six pre-school children[1] at the Child's Institute of the Johns Hopkins University. The types of observations made were as follows:

I. Three forms of manual tests were given under different experimental conditions for the purpose of ascertaining the preferential use of the hands in the situations presented. The results of these tests were compared with the so-called "native" handedness of the child. The criterion of "native" handedness adopted was the report by the parents of the manual bias exhibited by the child in daily activities. The hand favored in daily activities is referred to throughout this study as the "preferred" hand, whereas the hand not so favored is termed the "non-preferred" hand.

II. A study was made of learning by the non-preferred hand, and the transfer of training, if any, to the habitually preferred hand.

III. A training method was developed for practicing left-handed children in the use of the right hand in motor activities involving gross motor coördinations, as well as those involving the minute motor coördinations.

IV. Ten daily observations of 10 minutes each were made on each child in order to ascertain the preferential use of the hands, and the consistency of such preference, in daily activities of the child's own choice.

[1] All of the children were not used as subjects in each observation series, as this study extended over a period of four months or more, and some of the children were at the Institute for a two-week period only.

I. TESTS OF HANDEDNESS

The three tests employed were of the type in which manipulation may be either unimanual or bimanual. The situations imposed in the respective tests were as follows: in the first test, equal opportunity was provided for the use of either hand; in the second test, an inconvenience was imposed upon the use of the preferred hand; in the third test, rapid, spontaneous choice of hand was required.

Thirty subjects were used, ranging in age from 2 years to 6 years 8 months. While this number was not constant throughout all three tests, there was a nucleus of 24 subjects who performed in all tests and sections thereof. For the purpose of analysis, these subjects were divided into three handedness groups, namely, Right-handed, Left-handed, and Ambidextrous, this division being made on the basis of the report of the parents. These reports were confirmed in the case of twenty-one of the children by data gathered by the experimenter in the daily observation series reported in the fourth section of this study. Of the subjects who performed in all tests, 16 were right-handed, 6 were left-handed, and 2 were ambidextrous. The number of subjects in each age-group was as follows:

HANDEDNESS GROUP	AGE-GROUP				
	Two	Three	Four	Five	Six
Right	3	6	3	4	—
Left	—	1	1	2	2
Ambidextrous	1	—	1	—	—

In tests 1 and 2, the performance of several of the two-year olds was not considered with that of the remaining children in the group as these little ones did not complete the tests; however, the data regarding them were analyzed in so far as possible.

Test 1: The Marble Board

The activity involved in this test was that of picking up and placing, one by one, a series of similar objects. The condition

under which this test was given offered equal opportunity for the use of either hand.

Apparatus and procedure. The apparatus used was a Dunlap marble board, made of ebonized wood, $11\frac{1}{2}$ inches square and $\frac{7}{8}$ of an inch thick. This board was mounted upon two strips of ebonized wood, 11 inches long, $1\frac{3}{4}$ inches wide, and $\frac{7}{8}$ of an inch thick. The board contained 100 depressions of half inch diameter each, arranged in ten rows or columns of ten depressions, the depressions being equidistant from each other. Two marble boards were used in this experiment, each one being placed upon a separate table. The height of the table with the marble board on it was such that the child could lean over it and place the marbles with ease even on the top row. The tables were placed two feet apart. Directly in front of the marble board on each table was a box containing 100 white agate marbles. Thus, the marbles and the board were so arranged that manipulation by either hand was equally favored.

Two children were brought into the experimental room at the same time and were told to stand, one at each table, in front of the marbles and the marble board. The experimenter sat on a chair placed between the two tables, in order to prevent the children from stopping in their activity to watch each other. Instructions were given as follows: "Here is a marble board and a box of marbles for each of you. I want each of you to place your marbles in your board just as quickly as possible, and see who finishes first! Wait until I say 'Go'! Ready! Go!"

The performance of only one child of a pair was observed, and this child was then used as a competitor for the next performer. The competitor for the child observed in the first pair was a former attendant at the Institute, and her record was not included as part of this experiment. The element of competition was employed as an incentive toward spontaneous manual choice. The investigator observed which hand was employed by the child in picking the marbles from the box, and which hand was used in placing them in the recesses of the board.

Results. Variation was shown in all three handedness groups in the form of manipulation adopted, not only in the performance of different children, but also, in many cases, within the per-

formance of a given subject. Thus, while some children adopted a unimanual method throughout the test, others consistently used a bimanual method, and still others varied between these two types of performance. The bimanual method assumed four forms, in two of which the function of the two hands was different in kind, and in two, the function of the two hands was the same in kind. The methods adopted were as follows:

1. Picking and placing a sequence of marbles with one hand.
2. Picking the marbles (one at a time, or several) from the box with one hand, and placing them with the other.
3. Picking several of the marbles from the box with one hand, passing to the other hand to hold, and placing with the first hand, one by one.
4. Alternately picking and placing a marble with one hand, then with the other.
5. Picking and placing a marble with each hand simultaneously.

Right-handed group

There were 17 children in this group of 19 who completed the test. The average per cent of marbles manipulated according to each of the methods noted, by the group who completed the test, is as follows:

	METHOD 1		METHOD 2		METHOD 3		METHOD 4	METHOD 5
	(a)	(b)	(a)	(b)	(a)	(b)	Alt.	Simul.
Hand used to Pick	R	L	L	R	R	L	R L	R L
Hold					L	R		
Place	R	L	R	L	R	L	R L	R L
	80.2%	4.8%	6.7%	0.6%	1.8%	0	1.2%	4.7%

The average per cent of marbles picked and the average per cent placed by each hand, without reference to a specific method, is as follows:

	RIGHT HAND	LEFT HAND
Picked	85.5%	14.5%
Placed	91.6%	8.4%

The tendency of this group was toward a pronounced preference for the use of the right hand in both picking and placing the marbles. Fifteen of the seventeen children who completed the test used the right hand in manipulating from 75% to 100% of the marbles, the remaining two children showing no preference for either hand. Consistency in manual choice for the "preferred" right hand in picking and in placing all of the marbles was noted on the part of 9 children, representing approximately 54% of the group. Of these nine children, eight used the right hand exclusively to pick and place the marbles in a strictly unimanual form of manipulation; and one child used the right hand exclusively to pick and place the marbles, although she varied from a strictly unimanual performance to a form of the bimanual method in which the left hand held the marbles which had been picked, a number at a time, by the right hand, and passed by that hand to the left to hold. The remaining eight children varied the strictly unimanual method in which the right hand was used exclusively, with one or more of the other methods noted in which the left hand functioned exclusively, or in either picking or placing the marbles. Five of these eight children adopted the unimanual method favoring the right hand in the manipulation of at least the first fifty marbles, and then used other methods, frequently alternating thereafter between the use of the first method and the subsequent ones.

Fifteen children in this group started their performance by picking and placing the marbles with the right hand, one started picking and placing with the left hand, and one started by picking and placing a marble with each hand simultaneously.

In some instances, conditions were noted which may have been influential in producing a deviation from a dominant method. For example, one subject, when picking and placing a sequence of marbles with the left hand, would sometimes, on reaching toward the extreme right of a row, pass the marble to the right hand to place. A second subject, who used primarily the method of picking the marbles from the box with the left hand and passing them to the right hand to place, would occasionally, on reaching to the extreme left of a row, place the marble with the left hand in which it was held.

Two of the three two-year olds in this group did not complete the test. They became disinterested after having placed twenty or twenty-five, one of them discontinuing the task, although he apparently retained his interest in the marbles as objects to handle and roll about. The second subject reluctantly continued until she had placed fifty marbles, making a wry face during the latter part of her task. Then, suddenly announcing that she didn't want to play any more, she turned away from the board and ran from the room. This latter subject used the right hand exclusively to pick and place the fifty marbles. The first subject referred to was ambidextrous in his method, favoring first one hand, then the other.

Left-handed group

The average per cent of marbles manipulated according to each of the methods noted, by the group of six children who completed the test, is as follows:

	METHOD 1		METHOD 2		METHOD 3		METHOD 4	METHOD 5
	(a)	(b)	(a)	(b)	(a)	(b)	Alt.	Simul.
Hand used to Pick	R	L	L	R	R	L	R L	R L
Hold					L	R		
Place	R	L	R	L	R	L	R L	R L
	20.3%	31.3%	1.3%	1.7%	0	28.7%	5%	11.7%

The average per cent of marbles picked and the average per cent placed by each hand is as follows:

	RIGHT HAND	LEFT HAND
Picked	30.3%	69.7%
Placed	30 %	70 %

The general tendency on the part of the group was toward a pronounced preference for the use of the left hand in both picking and placing the marbles, although there was individual variation.

While none of the children in this group consistently used their habitually "preferred" hand throughout to pick and place the marbles, four children showed a marked preference for the left hand, picking and placing at least 80% of the marbles with that hand. Two of this group of four favored primarily the unimanual method of manipulation, picking and placing each marble with the left hand without any aid from the right hand; however, the other two subjects favored the bimanual method of picking up several marbles with the left hand, passing them to the right hand to hold, then taking them one by one from the right hand and placing them with the left hand. The two six-year-olds in this group showed no preference for the left hand, one of these children using primarily the method of picking and placing a marble with each hand, simultaneously, the other child definitely favoring the right hand, picking and placing 94% of the marbles with that hand and 6% only with the left hand. These two six-year-olds were kindergarten pupils.

All of the children in this group started their task by picking and placing the marbles with the left hand.

The two-year-old in this group did not complete the task, manipulating but 34 marbles. He showed no consistent preferential handedness, but varied his choice every two or three marbles.

Ambidextrous group

The two ambidextrous children who completed the test both showed a marked preference for the left hand, one subject using it exclusively to pick and place all of the marbles, the other subject varying this method to some extent with the other methods of manipulation in which the right hand functioned in whole or in part. The average per cent of marbles picked and the average per cent placed by each hand is as follows:

	RIGHT HAND	LEFT HAND
Picked	15%	85%
Placed	15%	85%

The two-year-old in this group manipulated but 17 marbles. No marked favor was shown to either hand, as this subject would alternately pick and place a few marbles with one hand, then a few with the other hand.

All three children began their task by picking and placing with the left hand.

Two-year-olds. The peg board

As the two-year-olds, with but one exception, had failed to complete the manipulation of the total number of marbles, and had apparently regarded the marbles as objects to roll, or to pick up and let fall through the fingers, another test was adopted for them, namely, the peg board. This, like the marble board, was arranged in such a way that manipulation by either hand was equally favored. The board used was made of selected stock of bass wood which did not indicate any grain. Twenty-five holes of $\frac{3}{8}$ inch diameter were bored therein, these holes being arranged in five rows or columns of five holes each, and were equidistant from each other. The board was 9 inches square, and three-quarters of an inch thick. The pegs which fitted into the holes were one-quarter of an inch in diameter, and 2 inches in length. The board and pegs were lacquered.

The peg board was placed upon a table sufficiently low to permit the child to lean over it and place the pegs with ease. The box of pegs was on the table directly in front of the peg board, thus being equally accessible to either hand. The children were brought into the room singly, and not in pairs as in the marble board test. The child was told to stand at the table in front of the pegs and peg board and was instructed as follows: "Do you see this peg board and these pegs? I want you to put the pegs into the board just as fast as you can!" This test was given to each child daily over a three-day period.

The subjects consisted of 3 right-handed children, one left-handed child, and one ambidextrous child.

The forms of manipulation employed were similar to those noted in the marble board test. In the right-handed group, all three children showed a decided preference for the right hand,

although they differed to some extent in the degree to which this bias was exhibited. The right hand was strongly favored by all three subjects in placing the pegs, subjects B and D using that hand exclusively, and subject C using it in placing all but 3 pegs. Subject D likewise showed a marked preference for the right hand in picking the pegs, using the left hand to pick but one of the total number of seventy-five pegs; while subjects B and C used the left hand to pick approximately 20% of the pegs. Subjects B and C showed some daily variation, each of them having used the right hand exclusively to pick and place the pegs on one day, while on the other two days they used the left hand to pick some of the pegs.

The one so-called left-handed child in this group of two-year-olds strongly favored the right hand in picking and placing the pegs on the first and second days; however, on the third day his manual choice was approximately equal for each hand.

The ambidextrous child favored the right hand to a greater extent than the left in both picking and placing the pegs; however, the degree of preference for the right hand in placing them was very small. This subject also showed variation in successive daily performances, using the right hand primarily on the first day for both picking and placing the pegs, favoring the right hand more frequently for picking and the left more frequently for placing on the second day, and on the third day favoring the left hand to a greater extent than the right in both picking and placing.

Test 2. The Formboard

The activity involved in this test was that of picking up, one by one, a series of objects or forms and placing them within the corresponding recesses of a formboard. The conditions under which the test was given involved a convenience to the use of the habitually preferred hand in the manipulation of half of the forms, and an inconvenience to the use of the habitually preferred hand in the manipulation of the other half of the forms. It was planned to ascertain whether, in the manipulation of the forms inconveniently placed with reference to the preferred hand, but

conveniently placed with reference to the non-preferred hand, the use of the "preferred" hand would persist despite the inconvenience; or whether the child would resort to the use of the "non-preferred" but convenient hand.

Apparatus and procedure. The apparatus used was the Cornell adaptation of the Seguin formboard. This modification of the Seguin formboard was well adapted to the conditions of this experiment in view of the fact that the forms fit into the recesses of a series of removable blocks, the position of which could be arranged to suit the requirements of this test. The wooden blocks containing the recesses, and which comprised the formboard, were placed from left to right in the following order:

First row—elongated hexagon, triangle, star
Second row—cross, circle, elongated diamond, lozenge
Third row—square, half circle, rectangle.

This arrangement was made for the purpose of dividing the board, in so far as possible, into a right half and a left half. Thus, the right side of the board contained recesses for the star, the lozenge, the rectangle, the triangle, and the elongated diamond; and the left side contained recesses for the elongated hexagon, the cross, the square, the circle and the half circle. The half circle extended slightly to the right of the median line of the board.

The blocks corresponding to the recesses were placed on the table, five at the right and five at the left of the formboard. Thus, in manipulating the forms lying at the side of the formboard corresponding to the "preferred" hand, termed the "preferred" side, a convenience was offered to the use of that hand, in that the forms were readily accessible to it; however, in manipulating the forms lying at the side of the formboard opposite to that corresponding to the "preferred" hand, termed the "non-preferred" side, an inconvenience was offered to the use of the preferred hand in that its use would involve reaching across the board. Four trials were given under somewhat varying conditions with reference to arrangement of forms at the right and left sides of the board. The arrangements were as follows:

Trial 1. The five blocks placed at the right of the formboard corresponded to the five recesses in the right section of the board, and were placed in a consecutive order, from top to bottom, those corresponding to the recesses at the extreme right of the board coming first, then those corresponding to the adjoining column. The order was: star, lozenge, rectangle, triangle, elongated diamond. The five blocks at the left of the board corresponded to the five recesses in the left section of the formboard, and were likewise placed consecutively, in so far as possible, those corresponding to the recesses in the extreme left column being placed first, then those corresponding to the recesses in the adjoining column. The order on the left side was: elongated hexagon, cross, square, circle, half circle.

Trial 2. The five blocks lying at the right of the formboard were those corresponding to the five recesses of the left side of the formboard, placed in the same order as in trial 1. Those lying at the left of the formboard corresponded to the five recesses in the right side of the formboard, placed in the same order as in trial 1. In other words, while the order in which the blocks were placed in the two columns was the same as in trial 1, the columns were reversed.

Trial 3. The five blocks lying at the right of the board corresponded to the five recesses at the right side of the formboard, as in trail 1; however, the order of the blocks was changed. The order was as follows: elongated diamond, rectangle, star, lozenge, triangle. Likewise, the five blocks lying at the left side of the board corresponded to the five recesses of the left side of the board, as in trial 1; however, the order of the blocks was different from that in the first trial. The order was: circle, square, elongated hexagon, half circle, cross.

Trial 4. The order in which the blocks were lying in the two columns was similar to that in trial 3; however, the columns were reversed. Thus, as in trial 2, the blocks in the column at the left of the formboard corresponded to the recesses in the right half of the formboard, while those in the column at the right of the formboard corresponded to the recesses in the left half of the board.

Each subject was given the four trials in consecutive order. The interval between trials was three minutes. During this period the experimenter removed the blocks from the recesses of the formboard and placed them at the sides of the board in the proper order for the next trial. The subject was in an adjoining room between trials. There was a sliding board in this room

and most of the children availed themselves of the opportunity for a slide before taking the next test. When the subject first entered the room, the blocks were arranged at the sides of the formboard, on the table, in the order given for trial 1. The table on which the formboard and blocks were placed, was in line with the door through which the child entered the room, so that the child's approach to the board should be directly from the front, in so far as it was possible to arrange this experimentally. After he had taken his place before the formboard, he was instructed as follows: "Let me see how fast you can put these blocks into place!" When the first trial was completed, the child was sent into the adjoining room, as noted above, until called for the second trial. He again entered the room through the door directly in line with the table and formboard, with the blocks to the right and left of the board. Instructions were given before each trial, although they were scarcely needed, as in all trials after the first the subject usually ran into the room when called, and running to the table, immediately began placing the blocks without waiting for instructions. The children were, without exception, greatly interested in the formboard.

The following observations were made by the experimenter of the performance of each subject: (1) the hand with which the subject picked up and placed the blocks which were lying at the right of the board, and those lying at the left of the board, in each trial; (2) whether the subject placed all of the blocks lying at one side of the board before placing any from the opposite side, or whether he shifted back and forth, from one side to the other; (3) whether the blocks were properly placed in their corresponding recesses; (4) whether the subject endeavored to finish his performance as quickly as possible.

It was noted that in many cases a child would pick up a form, with a given hand, place it above the recess with that hand, and then assist in placing it within the recess with the other hand, often pounding it in with that hand. Unless a form was definitely passed by the hand which picked it from the table to the other hand for placement in the recess, the second hand was not credited with placing the block.

Results.—

Right-handed group

The average per cent of blocks lying at the *right* side of the board which were picked and placed by each hand in each trial, as well as in the total number of trials, is given below.

	TRIAL 1		TRIAL 2		TRIAL 3		TRIAL 4		TOTAL	
	R	L	R	L	R	L	R	L	R	L
Hand used to Pick	100%	—	94%	6%	94%	6%	94%	6%	95.6%	4.4%
Place	100%	—	94%	6%	94%	6%	94%	6%	95.6%	4.4%

It appears that when objects were conveniently located with reference to the preferred hand, a pronounced preference was shown by all of the children in this group for that hand. Fourteen of the seventeen children in this group who had all four trails, representing approximately 84% of the group, consistently used the right hand in all four trials in picking and placing the blocks lying at the right of the board, regardless of whether the forms lying at the right of the formboard corresponded to the recesses in the right half or in the left half of the board. Three subjects, representing approximately 16% of the group, favored the right hand consistently in three trials and the left hand in one trial. The trials in which the left hand was used was a different one for each child. The 2 two-year-olds who completed only the first trial, both used the right hand to pick and place the forms lying at the right.

The average per cent of blocks lying at the *left* side of the formboard, which were picked and placed by each hand in each trial, as well as in the total number of trials, is as follows:

	TRIAL 1		TRIAL 2		TRIAL 3		TRIAL 4		TOTAL	
	R	L	R	L	R	L	R	L	R	L
Hand used to Pick	34%	66%	48%	52%	48%	52%	42%	58%	43%	57%
Place	42%	58%	54%	46%	54%	46%	44%	56%	48%	52%

The group average indicates a greater degree of preference for the left hand than for the right, particularly in picking the forms from the table, however there are wide individual differences. The degree of bias for the right hand in manipulating objects lying at the left, thus offering an inconvenience to the use of the habitually "preferred" hand, ranged from 100% choice for that hand to zero. The children tended to fall into three groups as follows: (1) those who, despite the inconvenience offered to the use of the right hand, nevertheless showed a pronounced tendency toward the use of that hand; (2) those who favored to a pronounced degree the "convenient" left hand; (3) those who showed no marked degree of preference for either hand. The second group was the largest, as 8 subjects, representing approximately 48% of the total number of subjects, used the left hand in manipulating from 66⅔% to 100% of the total number of forms lying at the left in the four trials. Next in size was group (1), as 6 subjects, representing approximately 35% of the group, favored the right hand in manipulating from 66⅔% to 100% of the total number of forms lying at the left. Three subjects, representing approximately 17% of the group, showed no marked favor for either hand.

Consistency of choice for a given hand in the total number of trials was shown by 5 children in this group, 3 of whom used the right hand exclusively to pick and place the five forms lying at the left of the board in all four trials, and 2 of whom used the left hand exclusively in these trials. The remaining 12 subjects in this group varied their manual choice in one or more trials. Four of these twelve subjects consistently used a given hand in manipulating the five forms lying at the left in any single trial, however they varied from trial to trial, using the right hand consistently in one or more trials, and the left hand consistently in the remainder. Four subjects consistently used a given hand in manipulating the five forms in each of three trials, but in one trial they varied their choice, manipulating one or more forms with the right hand and the remainder with the left. Four subjects were consistent in the use of a given hand in one trial only, and varied their manual choice within each of three trials. Thus,

while 54% of the subjects were consistent in the use of a given hand in each of the trials, considered separately, relatively few maintained consistency in manual choice throughout all four trials.

The five children who maintained consistency in manual choice throughout all four trials, in manipulating the forms at the left of the board, were all four-year olds. No significant age differences were noted with reference to the hand most frequently used.

Left-handed group

The average per cent of forms lying at the *left* side of the board, which were picked and placed by each hand in each trial, as well as in the total number of trials, is as follows:

	TRIAL 1		TRIAL 2		TRIAL 3		TRIAL 4		TOTAL	
	R	L	R	L	R	L	R	L	R	L
Hand used to Pick	—	100%	—	100%	—	100%	—	100%	—	100%
Place	—	100%	—	100%	—	100%	—	100%	—	100%

In this group, as in the Right-handed group, when objects are conveniently located with reference to the "preferred" hand, there is a pronounced preference for the use of that hand. The six children in this group who completed the four trials, all consistently used the left hand in picking and placing the blocks lying at the left of the formboard in all four trials. The two-year old who performed only one trial, likewise used the left hand exclusively in manipulating the forms lying at the left.

The average per cent of forms lying at the *right* side of the formboard, which were picked and placed by each hand in each trial, as well as in the total number of trials, is as follows:

	TRIAL 1		TRIAL 2		TRIAL 3		TRIAL 4		TOTAL	
	R	L	R	L	R	L	R	L	R	L
Hand used to Pick	47%	53%	83%	17%	50%	50%	60%	40%	60%	40%
Place	40%	60%	73%	27%	40%	60%	40%	60%	48%	52%

Some variation was shown with reference to the hand used in picking the forms and that one used in placing them. With reference to the total number of trials, the average per cent of blocks which were picked by the right hand predominates over the average per cent picked by the left hand, while in placing the blocks, the average per cent of left hand choices predominates slightly over the average per cent of right hand choices. This predominance of right hand choices in picking, and of left hand choices in placing, is not consistently shown, however, in each separate trial. As in the Right-handed group, there are wide individual differences.

Thus, when forms conveniently located with reference to the "non-preferred" hand, but inconveniently located with reference to the "preferred" hand, are manipulated, considerable variation in degree of bias for the "preferred" left hand was manifested. The degree of bias for the "inconvenient" left hand, as evidenced in the performance of the subjects in the total number of trials in manipulating the forms lying at the right of the board, ranged from 70% to 30%. The range of variation does not reach the limits attained by the Right-handed group in either direction, as none of the children consistently favored their "preferred" hand, nor did any favor their "non-preferred" but convenient hand exclusively, in all four trials. Thus, while none of the children in the Left-handed group indicated the strong degree of bias for their "preferred" hand which was evident in the performance of several children in the Right-handed group, on the other hand none of them adapted so thoroughly to the use of the "preferred" hand as did some of the children in the Right-handed group.

As in the Right-handed group, the children tended to fall into 3 groups as follows: (1) those who, despite the inconvenience offered to the use of the "preferred" hand, nevertheless showed a pronounced tendency toward the use of that hand; (2) those who favored to a pronounced degree the "convenient" but non-preferred hand; (3) those who showed no marked degree of preference for either hand. One child favored the left hand in manipulating approximately $66\frac{2}{3}\%$ of the forms; 3 children used the right hand in manipulating at least $66\frac{2}{3}\%$ of the forms; and 2

children showed no marked preference for either hand in picking the forms, although one of these two used the left hand primarily in placing them.

None of the children in this group showed a consistent preference for either hand in the total number of trials, nor did any of this group consistently use a given hand within each separate trial. Four children in this group consistently favored a given hand in one or more trials, and varied their manual choice within the remaining trials; and two subjects varied their manual choice within each of the four trials.

Ambidextrous group

The average per cent of forms lying at the *left* of the board, which were picked and placed by each hand in each trial, and in the total number of trials, is as follows:

	TRIAL 1		TRIAL 2		TRIAL 3		TRIAL 4		TOTAL	
	R	L	R	L	R	L	R	L	R	L
Hand used to Pick	13%	87%	7%	93%	—	100%	—	100%	5%	95%
Place	13%	87%	7%	93%	—	100%	—	100%	5%	95%

Although there is a slight variation in degree of left hand bias in the manipulation of the forms lying at the left, all three of the subjects in this group showed a marked preference for the left or "convenient" hand. One child consistently favored the left hand in all four trials, and two children favored the left hand consistently in three trials, and in one trial used the right hand to manipulate one or two forms.

The average per cent of forms lying at the *right* of the board which were picked and placed by each hand in each trial and in the total number of trials, is as follows:

	TRIAL 1		TRIAL 2		TRIAL 3		TRIAL 4		TOTAL	
	R	L	R	L	R	L	R	L	R	L
Hand used to Pick	100%	—	80%	20%	87%	13%	67%	33%	83%	17%
Place	100%	—	47%	53%	67%	33%	67%	33%	70%	30%

A greater extent of variability is exhibited here than in the manipulation of the forms lying at the left of the board, although here, also, the three subjects all tended to favor the hand conveniently located with reference to the desired object to a greater extent than the hand not so conveniently located. One child used the right hand consistently in all trials to pick up the blocks, and in 3 trials to place them, but varied her manual choice in placing them in one trial; one child favored the right hand in picking up and placing all forms in two trials, in picking up all forms in one trial and in placing all in one trial, although she varied her manual choice in these two trials otherwise; and one child used the right hand exclusively in two tests in picking and placing, favored the left hand exclusively in one trial, and varied her manual choice in one trial.

Thus, all three children in the Ambidextrous group favored the hand which was more conveniently located with reference to the desired object to a greater extent than the hand not so favorably located; although when the left hand was the convenient hand, the preference for it was evidenced to practically the same degree by all of the children, namely, almost exclusively; whereas when the right hand was the convenient hand, there was some difference in degree of preference for the right hand.

Transfer of blocks from one hand to the other. There were 3 children in the Right-handed group, 4 in the Left-handed group, and 2 in the Ambidextrous group, who occasionally transferred a form from the hand which had picked it from the table, to the other hand for placement. In the Right-handed group, these transfers occurred only when the forms lying at the left of the board were manipulated; and the transfer was in every case from the left hand which had picked up a form, to the right hand for placement. The transfers which occurred in the Left-handed and Ambidextrous groups were all found where blocks lying at the right side of the formboard were manipulated. The transfer in these cases was always from the right hand, which had picked up the block, to the left hand for placement. As in the case of the Right-handed group, these transfers were distributed over the total number of trials, and not confined to any one of them.

Thus it appears that, in both the Right-handed and Left-handed groups, transfers were made only when the non-preferred hand had picked up a form conveniently located with reference to it; and the "preferred" hand was then favored with the placing of the form. No age difference was noted in this respect, as this tendency was noted on the part of one or more of the subjects in each of the age groups.

Skipping from side to side in manipulating the forms. In the Right-handed group, five subjects adopted the method throughout all four trials of manipulating all of the forms lying at one side of the formboard before placing any from the opposite side. The remaining twelve children in this group skipped from side to side in one or more trials. In the Ambidextrous group, all three subjects skipped from side to side in one or more trials. Three subjects in the Left-handed group consistently manipulated all of the forms lying at one side of the formboard before placing any from the opposite side throughout all four trials. The remaining three subjects skipped from side to side in one or more trials.

The number of subjects in each group who skipped from side to side in the various trials was as follows:

HANDEDNESS GROUP	FIRST TRIAL	SECOND TRIAL	THIRD TRIAL	FOURTH TRIAL
Right	1	8	4	9
Left	1	3	1	2
Ambidextrous	1	2	0	1
	3	13	5	12

It will be noted that the tendency to shift from side to side occurred with much greater frequency in the second and fourth trials, in which the forms were lying at the side of the formboard opposite to that section which contained their corresponding recesses. No age differences were noted in this respect, as one or more of the subjects in each age group adopted this method of shifting from side to side.

Speed and accuracy of placing the forms. The children above

three years of age all made an apparent effort to place the forms as quickly as possible. The majority of the subjects above three years also apparently discriminated before placing the forms in their respective recesses. Three subjects over the age of three years used the trial and error method of manipulation during the first two trials, placing a form over first one recess, then another. Two of these subjects succeeded in placing all of the forms correctly in these two trials, as well as in the last two trials in which they apparently discriminated before placing the forms. One of these subjects made several errors in the first two trials, although in the last two trials all of the forms were placed by him correctly.

Only one of the five children under three years of age succeeded in placing all of the blocks correctly. These subjects used primarily the trial and error method, placing a block over one recess, then over the other, endeavoring to force it in, and frequently leaving the block lie above the wrong recess. Time counted for little with this group, as no effort was made by them to speed the performance, and a great deal of time was spent in laughing and chatting about where a given form would be placed.

There were two children in the Right-handed group and one in the Left-handed group who consistently started, in all four trials, to place first the forms lying at the side of the formboard corresponding to their preferred hand. While the remaining children in both groups varied in different tests, starting at the right in one or more tests, and at the left in the remainder, the tendency on the part of the majority of the subjects in both of these groups was to start manipulating the forms lying at the side corresponding to their "preferred" hand in the greater number of trials.

Analysis was made of the performance of those subjects who started first to manipulate the forms at the right in one or more trials, and in the remaining trials started first to manipulate the forms at the left, in an endeavor to ascertain whether there was any relation between the side at which the child started to work, and the arrangement of the forms at the side of the formboard

in the four trials. It was noted that in the Right-handed group, the cases in which the forms at the left of the board were manipulated first were distributed among the four trials, and not confined to the second and fourth trials, in which the forms at the left of the board corresponded to the recesses in the right side of the formboard. Likewise the cases in which the blocks at the right were first manipulated were distributed throughout the four trials. This was also true of the performances of those children in the Left-handed and Ambidextrous groups who showed variation with respect to the side from which they started in different trials. Thus it appears that, on the whole, the arrangement of the blocks at the side of the formboard opposite to that section which contained the corresponding recesses, in trials 2 and 4, did not direct the choice of blocks placed first in these trials, although this factor may have operated in individual cases.

An analysis was made of the performance of those subjects who exhibited diverse or varied manual choice in picking up the forms lying at the "non-preferred" side of the formboard, this diversity being manifested with reference to entire trials as opposed to other trials, or with reference to the manipulation of individual forms within specific trials. For example, an endeavor was made to ascertain whether there were any factors consistently accompanying the performance of a left-handed child who, in picking up the forms lying at the right of the formboard, used the left hand in one or more trials and the right hand in the remaining trials; or, who used one hand to pick up and place one or more forms within a given trial, and the other hand to manipulate the remaining forms. This analysis was likewise made with reference to the performance of the right-handed children with blocks lying at the left of the board. Variations in manual choice exhibited in the Ambidextrous group and by the three children in the Right-handed group who, in manipulating the blocks lying at the right of the board, used the left hand in one trial, were also included in this analysis.

The following conditions were found to occasionally accompany manual choice:

1. The hand with which a child started to manipulate the forms corresponded to the side of the board from which the forms were first taken.

2. The hand with which a child started to manipulate the forms at one side was used consistently throughout the placement on both sides in a given trial.

3. Variation in placement of forms by the experimenter at the side of the formboard in different trials was accompanied by variation in the child's manual bias.

4. Shifting from side to side in manipulating the blocks in a given trial was accompanied by the use of the same hand after the shift as before.

5. Passing a block from the hand which picked it from the table, to the other hand for placement, was followed by the continued use of the second hand in manipulating the next block.

6. The necessity of reaching for a block at the top of the column of blocks lying at the side of the formboard opposite that of the "preferred" hand sometimes called forth the use of the preferred hand, although the non-preferred hand was used in that specific test to manipulate all other blocks lying on that side.

While any one of these factors was occasionally found to accompany a given choice of hand which varied from the choice primarily favored, it cannot be stated conclusively that these factors were causal, as none of them was invariably present when variations in manual choice were noted. Also, the same manual choice did not invariably follow whenever a given factor was present, either in the performance of different children or in the performance of the same subject in different trials. For example, in one trial a child may have started placing forms lying at the left of the board, using the left hand. In another trial, the same child may have again started placing the blocks lying at the left, but this time the right hand was employed. Also, with reference to shifting from side to side, while in some cases the same hand was used in manipulating the first block only which was placed after the shift as was used immediately prior to the shift, in other cases the change from side to side was accompanied by the use of the same hand throughout the trial for manipulating the

forms on both sides; and in still other cases, where a shift from side to side was made, the manual preference invariably followed the side from which the blocks were taken, that is, the right hand manipulated the blocks lying at the right of the formboard, and the left hand manipulated those lying at the left side.

Test 3: The Picking-up-toy Test

The activity performed in this test was that of running as swiftly as possible for a desired object and bringing it to the experimenter. The condition imposed upon the subject by the nature of the task was rapid, spontaneous choice of hand. The test comprised three distinct sections, differing from each other in certain respects which are noted in the discussion of each specific section. A series of choices was made in each section, in order to ascertain consistency of manual preference in repetitions of the task.

Section 1

Two objects were employed as stimuli for response in this section of the test. The purpose was to ascertain whether the child would grasp one of the objects with the habitually preferred hand, pass it to the non-preferred hand to hold, then grasp the second object with the preferred hand; or whether he would reach for the objects with both hands simultaneously. That is to say, would the child give to the habitually preferred hand the active part of the performance, and to the non-preferred hand the passive function? Or would the two hands function in the same type of performance? If the latter method were used, would the preferred hand be favored in point of time in that it would reach out before the non-preferred hand?

Apparatus and procedure. The objects used were two orange rubber kitty cats, about one foot in height, of the type which expanded when air was blown into them. They stood in upright position, on the hind legs, with the front legs extended in armlike fashion. They were dressed in bright colored garments which called forth the admiration of all of the children. In fact, without exception, the kitty cats were a source of extreme delight to all.

They were called "Flopsy" and "Mopsy," the names having been bestowed upon them by one of the children and speedily adopted by the rest.

These kitty cats were placed side by side in a tin basket which was painted in gold and black. They were so arranged that the head and upper part of the body of each cat projected above the rim of the basket. Thus the cats were visible and easily accessible to the subjects. The basket was then placed at one end of the room, about two feet in front of a window, and six feet from the experimenter. The cats were resting against the side of the basket nearest the window and thus were directly facing the experimenter and subject.

The children were brought into the room in pairs and were given turns alternately in running for the kitty cats. The experimenter endeavored to place the child directly in line with the cats so that, in so far as it was possible to arrange them, conditions would favor a frontal approach to the desired objects. After releasing her steadying hold, she gave the following instructions: "When I say 'go,' I want you to run just as fast as you can to the basket and bring me the kitty cats. Do you understand? Now, Go!" The experimenter recorded the following: (1) the position assumed by the child at the basket—whether he stood directly in front of the kitty cats, toward the right, or toward the left; (2) the hand which first reached out and picked up a kitty cat; (3) whether any transfer was made of the cats from one hand to the other; (4) the direction in which the child turned after securing the cats. After the first child completed the first trial, the cats were replaced in the basket by the experimenter, and the second child was given a trial. Alternate trials were taken until each child of a pair had three trials. Three daily series of trials were given, making a total of 9 trials for each child.

Results. The various forms of manipulation employed, together with their corresponding symbols, are as follows:

RL(S)—both hands function *simultaneously*, each one grasping a kitty cat.

R— right hand seizes both cats at the same time.

R-R— right hand seizes one kitty cat, passes to left hand or arm to hold; then right hand seizes the second kitty cat.
R-L— right hand first grasps a cat, then the left hand grasps one.
L-R— left hand first grasps a cat, then the right hand grasps one.

The average per cent of trials in which the respective forms of manipulation were favored by each handedness group is as follows:

	RL(S)	R-L	L-R	R	R-R
Right-handed group	73.6%	19.4%	4.9%	1.4%	0.7%
Left-handed group	92.6%	7.4%	—	—	—
Ambidextrous group	66.7%	33.3%	—	—	—

It will be noted that no preference was shown, in any of the three handedness groups, to either the right or left hand with reference to type of function; nor was either hand favored to any significant extent in point of time, in so far as the experimenter was able to ascertain by direct observation; as the method of manipulation primarily employed by practically all of the children was that of reaching for and grasping a kitty cat with each hand simultaneously. Of the 16 subjects in the Right-handed group, 5 used the simultaneous method exclusively; 8 used both hands simultaneously in at least two-thirds of the number of trials; and 3 used the simultaneous method in from one to five trials. The method next in order of frequency was that of reaching first with the right hand for one kitty cat, then with the left hand for the other one, with a short interval between these two reactions. In the Left-handed group, 4 of the 6 subjects used the simultaneous method exclusively; one subject used it in 8 trials and used the R-L method in one trial; and one subject used the simultaneous method in 6 trials and the R-L method in 3 trials. One of the two ambidextrous children used the simultaneous method exclusively in all nine trials. The other child used it in 3 trials, and used the R-L method in 6 trials.

Thus, in situations of this type, when two objects of the same

kind, in proximity to each other, are to be secured under the conditions imposed in this experiment, namely, rapid, spontaneous choice of hand, the young child apparently does not specialize in the use of the hands, using one exclusively to reach for an object and the other to hold it; but the hands function primarily in unison, in the most efficient, convenient manner under the circumstance.

Considerable variation was shown with reference to position assumed by the subject at the basket prior to reaching for and grasping the desired object. Relatively few children in any of the groups maintained consistency of position in all trials. In the Right-handed group, 3 of the 16 subjects assumed the same position in all nine trials, one of these children standing center, and two standing right. In the Left-handed group, one of the 6 subjects consistently stood left in all trials. The average per cent of trials in which each position was assumed by the subjects in each of the three groups is as follows:

GROUP	RIGHT POSITION	LEFT POSITION	CENTER POSITION
Right-handed	38 %	16%	46 %
Left-handed	20.4%	37%	42.6%
Ambidextrous	72 %	6%	22 %

The center or front position was favored more frequently than either the right or left, by both the Right-handed and Left-handed groups, although there was individual variation in this respect in both groups. In the Right-handed group, the right position was favored next in degree of frequency; in the Left-handed group, the left position was next in favor. The two ambidextrous subjects both favored the right position more frequently than either the left or center.

The average per cent of turns to the right and to the left, after the kitty cats had been seized, in relation to position assumed by the subjects at the basket prior to reaching for the kitty cats, is given below:

GROUP	RIGHT POSITION		LEFT POSITION		CENTER POSITION	
	Direction of turn					
	R	L	R	L	R	L
Right-handed	3.6%	96.4%	86.4%	13.6%	40%	60%
Left-handed	9 %	91 %	95 %	5 %	25%	75%
Ambidextrous	—	100 %	100 %	—	25%	75%

Apparently there is an inverse relation between right or left position and direction of orientation, since in all three groups, after the object was secured when the subject stood at the right of the basket, the direction of orientation was almost invariably toward the left; and when the left position was assumed by the subject at the basket, the direction of orientation was primarily to the right. When central position was maintained, the majority of turns made in all three groups was toward the left.

Consistency in direction of turn was shown by 6 children in the Right-handed group and 2 children in the Left-handed group. Two of the right-handed children had stood right in all trials; 3 had stood either right or center; and one had stood right or center in 8 trials, and left in one trial. These six subjects all turned left in the 9 trials. One of the left-handed children stood left in all nine trials, and turned right consistently; the other child stood right or center in 8 trials, and left in one trial, and her direction of turn in all trials was to the left.

Section 2

In this section of test 3, a single object was the stimulus for reaction in a situation imposing rapid, spontaneous choice of hand. The desired object was equally accessible to either hand when approach thereto was in a straight line from the starting point. No provisions were made in the conditions of the experiment, however, to preclude deviations from a straight line approach.

Procedure. One of the kitty cats used in the previous section was utilized in this test series. As in the previous experiment,

the kitty cat was perched in the tin basket, so arranged that the head and upper part of the body projected above the rim of the basket, and was thus visible and easily accessible to the subject. The basket was again placed at one end of the room, about two feet in front of a window, and six feet from the experimenter. The cat was resting against the side of the basket nearest the window, and thus was directly facing the experimenter and subject.

Three daily series of trials were given, each series consisting of 3 trials, making a total of 9 trials for each child. The children were brought into the room in pairs and were given turns alternately in running for the kitty cat. Instructions were similar to those given in the first section, except that the words "that kitty cat" were used in place of "those kitty cats." Again record was taken of (1) the position assumed by the child at the basket—whether in front of the basket, to the right of it, or to the left; (2) the hand with which the cat was grasped; (3) the direction of turn after the cat was secured; (4) whether the cat was transferred to the other hand by the child on returning from the basket to the starting point.

Results. 1. Manual preference. Three types of manipulation were employed by the subjects in this test series, two of them being unimanual in nature, and one bimanual. That is, the cat was grasped with either the right hand, or the left hand, or with both hands simultaneously.

Right-handed group

The average per cent of choices for each of the three types of manipulation evidenced by this group in each daily series of trials, as well as in the total series of nine trials for each subject, is as follows:

MANUAL CHOICE	FIRST DAY	SECOND DAY	THIRD DAY	TOTAL SERIES
Right	56.3%	70.8%	60.4%	62.5%
Left	23 %	16.7%	29.2%	22.9%
Both	20.7%	12.5%	10.4%	14.6%

Although the general tendency of this group was toward more frequent manipulation with the right hand than with the left hand, there was considerable individual variation in degree of choice. While the average per cent of right hand choices in the total series was 62.5%, the range of choice for the right hand was from 100% to zero. Twelve subjects, representing 75% of the group of 16 subjects, showed a marked preference for the right hand, eleven of these children using it in from 66⅔% to 100% of the total number of trials, and one subject using the right hand in approximately 44% of the trials, and both hands simultaneously in the remaining trials; one child showed no marked favor to either hand; and 3 children favored the left hand to a greater degree than the right, one of these three subjects not using the right hand alone in any trial, but favoring primarily the use of both hands simultaneously.

Consistency in manual choice in all nine trials was shown by 2 subjects only, both of these children using the right hand exclusively. One was a two-year-old and one a three-year-old. However, analysis of the daily series of three trials each indicated that with but one exception, the children in this group were consistent in their manual choice in the three trials of at least one day.

Left-handed group

The average per cent of choices for each of the three types of manipulation evidenced by the group in each of the daily series of trials, as well as in the total series, is as follows:

MANUAL CHOICE	FIRST DAY	SECOND DAY	THIRD DAY	TOTAL SERIES
Right	14.3%	14.3%	14.3%	14.3%
Left	62 %	71.4%	76.2%	70 %
Both	23.7%	14.3%	9.5%	15.7%

The general tendency of this group was toward a pronounced bias for the left hand. Although there was some variability in response, both with respect to the preferential manipulation exhibited by the individual children in the total series of trials,

and in the performance of any given child in successive daily tests, with but one exception the children in this group definitely favored the left hand. While the average per cent of left hand choices was 70%, in the total number of trials, the degree of bias for the left hand ranged from 100% to zero. Five subjects used the left hand in from $66\frac{2}{3}\%$ to 100% of the total number of trials; one subject used the left hand in 44% of the total number of trials and both hands simultaneously in the remaining trials; and one subject did not use the left hand alone in any of the trials, but used the right hand in eight trials and both hands simultaneously in one. This latter subject was one of the two kindergartners previously referred to.

Consistency in manual choice in the total number of trials was shown by 2 children, both of these using the left hand exclusively. Analysis of the daily series of 3 trials each, indicates, however, that with but one exception the children in this group showed consistency in manual bias on at least one day.

Ambidextrous group

The performances of the three children in this group varied considerably from each other. One child used the left hand consistently in all three trials on each of two days, and used each of the three types of manipulation in one of the trials on one day. Another child used both hands simultaneously in all three trials on each of two days, and used both hands simultaneously in two trials and the left hand in one trial, on one day. The third child in this group consistently favored the right hand in all trials on one day, and on each of the other two days he favored the left hand in two trials and the right hand in one trial. Thus, not only was there variability in the performance of the children with respect to each other, but all of the children varied to some extent in the trials on different days.

2. Preferential manipulation and position. Although the variability in response found in all three handedness groups may be due to individual differences in the nature of the right or left hand drive or urge, suggestive of degrees of manual bias, various environmental factors may contribute to this variability, modifying

to some extent the "native" tendency. One of these factors is the position assumed by the child at the basket—whether he stood directly in front of the basket, at the right, or at the left.

Two facts must be noted with reference to the designation of position assumed by the child as right, left, or center. First, with reference to the center position: as this designation is based entirely on the observation of the experimenter, it is possible that in some instances where a child is termed as having assumed a center position, his position might have been to the right or left, but to so slight an extent that it was impossible to discern by simple observation; nevertheless, the extent may have been sufficient to influence the child's performance, in so far as the positional factor operates in manual choice. Secondly, the assumption of a right or left position at the basket is not a simple two-positional affair, but presents a variety of situations, in that, (1) there are variations in the degree of deviation to the right or left from a straight line approach to the object, and (2) there are variations in the angular incidence of the body in relation to the object grasped. That is to say, a child might assume a position at the front of the basket, somewhat to the right of a straight line approach to the object, yet its body might be in such a position that an imaginary plane drawn through the long axis of the body dividing it into an anterior and posterior section would be at right angles to the straight line approach to the object. In that case, the *left* hand of the child would be nearer the object than the right hand. Or, the child might assume a position to the right of the straight line approach, but turn his body toward the basket and the kitty cat, in which case the *right* hand would be nearer the object than would be the left hand. One subject frequently ran past the right side of the basket, reaching out as he ran with the left hand, which, under this condition, was nearer the kitty cat than was the right hand. Another child would run past the basket at the left, then would made a complete right turn at the rear of the basket though remaining at the same side of the basket, and would then thrust out the left hand, which under these conditions was nearer the desired object, and would grasp the kitty cat with that hand. A third child would some-

times do this when at the right of the basket; that is, he would run past the basket at the right, make a complete left turn, though remaining on the same side of the basket; and would then thrust out the right hand, which was nearer the object, and grasp the kitty cat with it.

Right-handed group

The tendency of the Right-handed group was to favor the position at the right of the basket to a greater extent than either the left or center position; in fact, to a greater extent than both of these positions combined. Of the total of 144 trials, the right position was assumed in 75 trials, or 52% of the total number; the left position in 36 trials, or 25% of the total number; and the center position in 33 trials, representing 23% of the total. With reference to individual choices, 11 subjects, representing 68.75% of the group, favored the right position more frequently than the left, although 2 of these subjects favored the central position more frequently than the right; and 5 subjects favored the left position more frequently than the right.

The average per cent of choices favoring each of the three methods of manipulation in each of the three positions assumed is as follows:

HAND USED	RIGHT POSITION	LEFT POSITION	CENTER POSITION
Right	77.3%	36.1%	57.6%
Left	17.3%	41.7%	15 %
Both	5.4%	22.2%	27.4%

When the position at the right of the basket was assumed, the tendency to use the right hand in reaching for and grasping the kitty cat was pronounced on the part of the majority of the subjects. Of the 13 children who assumed the position at the right of the basket in one or more trials, 8 did not favor the left hand in any trials in this position, six of these eight subjects favoring the right hand exclusively, and two of them using both hands simultaneously in one trial and the right hand in all others; two subjects used the right hand in the majority of the trials in that

position and the left hand in one or two trials; one used the left hand in the majority of the trials and the right hand in but one; and two subjects did not use the right hand at all when standing at the right, but favored either the left hand or the use of both hands simultaneously. The child who used the right hand in but one trial and the left hand in the remaining trials, was the one referred to on a preceding page, who would run past the basket at the right, and as he passed, would reach out with the left hand, which under these conditions was nearer the object, and would grasp the kitty cat with that hand. Nothing was noted in the performance of the other children in this group who occasionally used the left hand when standing at the right, which might account for that preference. One of the two children who had consistently used the right hand in all nine trials to grasp the kitty cat had stood at the right in all trials, and the other child had stood right in seven trials and center in two trials.

When the position at the left was assumed by the children in this group, considerable variation was shown in manual choice. Of the nine children in this group who assumed the left position in one or more trials, four did not use the right hand at all but used either the left hand or both hands simultaneously, two did not use the left hand in any trials but varied between the use of the right hand and both hands simultaneously; two used the right hand in some trials and the left hand in others; and one child used each of the three forms of manipulation in one trial each.

When the position at the center or front was assumed by the children in this group, there was a pronounced tendency toward the use of the right hand in preference to the left on the part of the majority of these subjects. Of the ten children who adopted the center position in one or more trials, seven did not use the left hand in any of the trials, and three used the left hand in one or two trials and the right hand or both hands simultaneously in the remaining trials in this position.

Left-handed group

In the total number of 63 trials made by all subjects in this group, the right position was assumed in 31.7% of the trials;

the left position in 28.6%; and center position in 39.7%. Considerable variability was shown by the children in this group with reference to position assumed at the basket, two of them favoring the right position in the majority of trials, two favoring the left position, and two favoring the center position.

The average per cent of choices favoring each of the three methods of manipulation in each of the three positions, is as follows:

HAND USED	RIGHT POSITION	LEFT POSITION	CENTER POSITION
Right	40%	5.5%	0
Left	55%	94.5%	66.7%
Both	5%	0	33.3%

When the position at the right of the basket was assumed, the performances of the three children who assumed this position varied from each other, although each child was practically consistent in its manual choice in this position. One subject used the right hand in all eight trials made when standing at the right; one child used the left hand in eight trials in this position; and one child used the left hand in three trials and both hands simultaneously in one trial.

When the position at the left of the basket was assumed, little variation in preference was shown, either in the various trials of any given child, or in the performance of the four different children who assumed the left position. Of the eighteen choices made in the left position, seventeen favored the left hand and one the right hand. Thus, as in the Right-handed group, when the position at the basket was on the side corresponding to the habitually preferred hand, that hand was given pronounced preference.

When the center or front position was assumed, the right hand was not used in any of the trials. Four of the children used the left hand only; one child used both hands simultaneously in the one trial made by him in this position; and two children used

either the left hand or both hands simultaneously. This performance, also, is similar to that of the Right-handed group, in that the hand habitually preferred in daily activities was favored to a pronounced extent when the center position was assumed.

Thus, in both the Right-handed and the Left-handed groups, the greatest extent of variability in preferential manipulation was noted when the position at the basket was on the side opposite to that of the "preferred" hand. When the position corresponding to the habitually preferred hand was adopted, or when a center position was assumed, there was a pronounced bias in favor of the "preferred" hand in both groups.

Ambidextrous group

One of the three subjects in this group assumed a position at the left of the basket in all 9 trials; one stood at the right in 5 trials, and at the left in 4 trials; and one stood right in 5 trials, left in 3 trials, and center in one. Thus, in the total number of trials made by this group, the right position was assumed in 10 trials, or 37% of the total; the left position in 16, or 59.3%; and center position in but 1 trial, representing 3.7%.

The average per cent of choices for each type of manipulation in each of the positions was as follows:

RIGHT POSITION			LEFT POSITION		
Hand used					
R	L	B	R	L	B
60%	40%	—	6.2%	43.8%	50%

In the one trial made in center position, both hands were used simultaneously.

3. Direction of orientation and position at the basket. The average per cent of turns to the right and to the left, after the kitty cat had been seized, in relation to the position assumed by the subject at the basket prior to seizing the desired object, is as follows:

GROUP	RIGHT POSITION		LEFT POSITION		CENTER POSITION	
	Direction of turn					
	R	L	R	L	R	L
Right-handed	—	100%	97.2%	2.8%	27.3%	72.7%
Left-handed	—	100%	100 %	—	40 %	60 %
Ambidextrous	—	100%	100 %	—	—	—

It will be noted that in all three handedness groups, when a position to the right or to the left of the basket was assumed by the subject prior to reaching for and grasping the desired object, after it was secured orientation of the subject was almost invariably in the direction opposite to that of the position maintained, regardless of the manual choice exhibited in the trials. In all but one trial in a total of 175, orientation was inversely related to position assumed. This one exception was noted in the performance of a right-handed child who stood at the left in 8 trials, in seven of which he turned right after grasping the kitty cat, and in one he turned left. No factor was observed which might have occasioned this variation.

When the center or frontal position was maintained, variation in direction of turn was observed in both the Right-handed and the Left-handed groups with reference to the performance of different children, and also with reference to the various trials of specific subjects. In the Right-handed group, 6 of the 10 children who stood center in one or more trials favored the left turn only; 2 favored the right turn only; and 2 varied between the right and the left. In the Left-handed group, one child turned right in 7 trials and left in 2 trials when standing center, and one turned left in 7 trials and right in one trial. Of the five children who stood center in one or two trials, three turned left, one turned right, and one varied the direction of turn in different trials. The one ambidextrous child who stood center in one trial turned left.

Section 3

As in section 2, a single object was the stimulus for reaction. The effort was made to eliminate, in so far as possible, the effect

of position as a factor in manual choice, by placing the object in such a way that deviations to right or left from a straight line approach from the starting point would be precluded, thus rendering the object equally accessible to either hand.

Procedure. One of the kitty cats used in section 1 was utilized in this series. The kitty cat was placed on a bench, approximately 4 feet long, 1 foot wide, and 1 foot 6 inches high. This bench was placed against the wall, with the kitty cat in the center of it, resting against the wall.

One series of 3 trials was given to each child. These trials could not be continued over a three-day period as was done in the preceding section, owing to the fact that the time was approaching for the close of the Institute during the summer months. The children were again brought into the room in pairs, and, as in the two previous sections, were given turns alternately in running for the kitty cat. Instructions were similar to those given in the first section, except that the words "that kitty cat" were used in place of "those kitty cats." Record was taken of (1) the hand with which the cat was grasped, and (2) the direction in which the subject turned after the desired object was secured. In this test series, as in section 2, three types of manipulation were employed, namely, the use of the right hand, the left hand, or both hands simultaneously reaching for and grasping the object.

Results. 1. Manual preference.—

Right-handed group

The average per cent of choices for each of the three types of manipulation employed by this group in this three-trial series is as follows:

Right hand: 58.3% *Left hand:* 27% *Both hands:* 14.7%

The general tendency of the children in this group was toward more frequent manipulation with the right hand than with the left, or with both hands functioning simultaneously, although there was some individual variation. Consistency in type of

manipulation in the three trials was shown by 11 children, 7 of them consistently using the right hand, 2 consistently using the left hand, and 2 using both hands simultaneously in all trials.

The results obtained in this three trial series were compared with those found in each of the daily three-trial series in section 2, with respect to degree of preference for the right hand, and consistency of manual preference in a three-trial series of choices. The number of children who consistently favored any one of the three forms of manipulation in the three consecutive trials of each daily series in section 2, and in the three trials of section 3, respectively, is as follows:

DAILY SERIES OF 3 TRIALS EACH	SECTION 2			SECTION 3
	1	2	3	
Form of manipulation:				
Right hand	5	9	6	7
Left hand	2	0	2	2
Both hands simultaneously	2	1	0	2

It will be noted that, with respect to the number of children who consistently used a given form of manipulation in the three consecutive trials of a one-day series of choices, the results found in section 3 did not vary from those found in any one of the three daily three-trial series in section 2 to any greater extent than did these daily series vary from each other. In fact, as far as consistency in right hand preference was concerned, the degree of difference between the second and first daily series, and between the second and third daily series, respectively, in section 2, was greater in both cases than that between section 3 and any one of the three daily series in section 2. It will also be noted that the average per cent of choices made by this group for the right hand and for the left hand respectively in section 3 does not vary from the average per cent of choices for each of these forms of manipulation in the first daily series or in the third daily series of section 2 (as shown on page 35), to any greater extent than do the average per cents of such choices in the first and third series vary from

each other; and the extent of variation in average per cent of choices for the right hand and for the left hand between section 3 and the first or the third daily series of section 2 is much less than the variation in this respect between the second daily series and the first and third respectively of section 2.

Left-handed group

The average per cent of choices for each of the three types of manipulation employed by this group in this three-trial series is as follows:

Left-hand: 77.8% *Right-hand:* 22.2% *Both:* 0

The general tendency of the children in this group was toward more frequent preference for the left hand than for the right. There was some individual variation with respect to degree of bias for the "preferred" hand, as 2 of the children used the left hand in all three trials, and the remaining 4 children used the left hand in two trials and the right hand in one trial. No significant difference was noted between the results in this three-trial series and any one of the three daily series in section 2.

Ambidextrous group

The three children in this group favored primarily the use of both hands simultaneously in the trials of section 3. Two of these subjects used this method exclusively, and the third child used it in two trials, and used the right hand alone in one trial.

2. Orientation and manual choice.—

Right-handed group

The average per cent of turns to the right and to the left, after the kitty cat had been secured, in relation to each of the three types of manipulation employed, is as follows:

RIGHT HAND USED		LEFT HAND USED		BOTH HANDS USED	
Direction of turn					
R	L	R	L	R	L
32.2%	67.8%	23%	77%	57%	43%

Although the average per cent of turns to the right and to the left indicates that the tendency of the group was toward a greater degree of preference for the left turn following the use of the right hand as well as the use of the left hand, nevertheless there was considerable individual variation. Of the 7 subjects who had used the right hand consistently in the 3 trials, 3 of these turned to the left in all trials, 1 turned to the right, and 3 varied the direction of turn in different trials. Both of the subjects who used the left hand in all 3 trials, turned left following seizure of the kitty cat. One of the 2 subjects who used both hands simultaneously in all trials turned right in all trials, and one varied her direction of turn in different trials. Of the 5 subjects in this group who showed variation in manual choice, 2 consistently evidenced inverse relationship between manual choice and orientation, turning right after the left hand had been used, and left after the right hand had been used; 2 consistently turned left, regardless of the hand used; and one subject turned left in 2 trials, in one of which the right hand was used, and one the left, and turned right in one trial following the use of the left hand. Thus, it appears that in this group no invariable relationship was exhibited between manual choice and direction of turn following seizure of the desired object, as 5 subjects consistently exhibited inverse relationship between manual choice and orientation; 3 children exhibited direct relationship, turning right following the use of the right hand, and left following the use of the left hand; and 7 children varied, showing a direct relationship in one or more trails, and inverse relationship in others. It may be that some other factor, such as final foot position just prior to reaching for the kitty cat, conditions the direction of turn. No consistent relationship was exhibited between direction of turn and manual "types", as 7 of these right-handed children turned left in all trials; 2 turned right in all trials, and 7 varied their direction of turn in different trials.

Left-handed group

The average per cent of right and left turns following each of the types of manual choice exhibited by this group, is as follows:

RIGHT HAND USED		LEFT HAND USED	
Direction of turn			
R	L	R	L
—	100%	64.3%	35.7%

The total number of trials made in this group is too small to warrant any generalization. There were but 4 right-hand choices made, all of these being followed by the left turn. When the left hand was used, there was some variation, as 3 children turned to the right, one child turned left, and 2 children varied in direction of turn in different trials. In this group as in the Right-handed group, no constant relationship between direction of turn and manual choice was apparent, as 3 children exhibited inverse relationship between manual choice and direction of turn, and 3 children varied, showing inverse relationship in one or more trials, and direct relationship in the remainder. No consistent relationship was shown between direction of turn and manual "types", as 1 of these left-handed children turned right in all trials; one turned left in all trials; and the remaining 4 children varied in direction of turn.

Ambidextrous group

Little opportunity was afforded to study the relation of turn to manual choice in this group, as there was only one trial in which the right hand was used alone, and none in which the left hand was used alone. In this one trial, orientation was to the left. Where both hands were used simultaneously, right turns predominated to a marked degree. One child turned right in all trials, and two children turned right in two trials and left in one trial.

Relatively little variation in type of performance was shown by any of the children in the three sections of this test. That is to say, where a child had exhibited a pronounced degree of preference for the right hand, or for the left hand, in any given section, the tendency was, on the whole, toward the same type of per-

formance in the other sections. Although variations did occur, as for example, in the performance of a few subjects in the three-trial series of section 3 as compared with section 2; these variations were no different in kind or degree than those found in section 2 between the various daily three-trial series.

There were but few children in any of the three handedness groups who maintained consistency in direction of orientation throughout all trials of the three sections of test 3. In the Right-handed group, 4 subjects, representing 25% of the group turned to the left in the total number of trials in all three sections of this test, namely, twenty-one trials; and in the Left-handed group, one child consistently turned right in all trials. The remaining children in these two groups varied in direction of turn in different trials, some favoring the right turn more frequently, some favoring the left turn primarily; however, in both groups the majority of children turned more frequently to the left. No factor was noted which might explain the marked preference for the left turn.

A comparison of the performance of each subject in the various tests

A comparison was made of the performance of each subject in tests 1 and 2, and in section 2 of test 3, respectively, for the purpose of ascertaining the consistency of manual bias exhibited by each child in the various tests. Sections 1 and 3 respectively of test 3, the picking-up-toy test, were not included in this comparison, for the following reasons: in section 1, the form of manipulation primarily favored by all of the subjects was that of reaching with both hands simultaneously, grasping an object in each hand; in section 3, the number of trials given were too few to warrant generalizations as to preferential handedness.

Right-handed group

The per cent of choices made in favor of the right hand by each subject in tests 1 and 2, and in section 2 of test 3, respectively, is shown in table 1. Of those subjects who did not use the right hand exclusively in a given test, some performed the remaining

trials by the use of both hands simultaneously, some used the left hand alone for all trials in which the right hand was not used, and some used both of these methods. A single asterisk placed beside the per cent of right hand choices in table 1 indicates that the remaining trials were performed by both hands functioning simultaneously; a double asterisk indicates that part of the remaining trials were performed by the left hand alone and part by both

TABLE 1

Right-handed group

Per cent of choices favoring the *right* hand in the respective tests

SUBJECT	AGE	TEST 1: MARBLE-BOARD	TEST 2: FORMBOARD		TEST 3: PICKING-UP-TOY
			Right side	Left side	
B	2′ 6″	97%	100%	0	66.7%**
C	2′ 7″	62%	100%	0	100 %
D	2′ 11″	100%	100%	45%	78 %
F	3′ 11″	75%	75%	25%	11 %
G	3′ 9″	90%	75%	5%	90 %
H	3′ 10″	100%	100%	75%	44.4%*
I	3′ 11″	92%	100%	15%	100 %
J	3′ 4″	100%	100%	45%	66.7%*
K	3′ 11″	100%	100%	5%	44.4%**
N	4′ 5″	50%	100%	0	0**
O	4′ 5″	100%	100%	100%	78 %
P	4′ 9″	100%	100%	70%	66.7%
R	5′	100%	100%	100%	22 %**
S	5′ 2″	50%	100%	75%	78 %
T	5′ 3″	85%	75%	50%	90 %*
U	5′ 4″	100%	100%	10%	66.7%**

hands simultaneously. Where no asterisk appears, the trials in which the right hand was not used alone were performed by the left hand, functioning alone.

Analysis of table 1 indicates that while none of the children in this group consistently used their habitually preferred right hand, alone, in all trials of all three tests, there were a few who showed a pronounced preference for the right hand in all tests; and the

majority of this group showed a marked preference for the right hand in tests one and three respectively, and in manipulating the forms at the right of the formboard in test two.

Three subjects, H, O and P, representing 18.75% of the group, showed a definite bias for the right hand in all three tests. These children used the right hand exclusively in manipulating the one-hundred marbles in test 1, and in manipulating the forms at the right of the formboard in test 2. In manipulating the forms at the left of the board, subject O used the right hand exclusively, and subjects H and P used the right hand in the majority of trials. In section 2 of the Picking-up-toy test, while none of these subjects used the right hand exclusively in all trials in the total three-day series, each one used the right hand exclusively in the three trials of at least one daily series; and all three used the right hand to a much greater extent than the left. In fact, subject H did not use the left hand alone in any of the trials in section 2 of test 3.

Eight subjects B, C, D, G, I, J, T and U, representing 50% of the group, showed a pronounced bias for the right hand in all tests except in that section of test 2 in which the forms at the left of the formboard were manipulated. Five of these subjects, B, C, G, I and U, favored the left hand to a pronounced degree in that section of the formboard test; while three of the subjects, D, J and T, did not favor either hand to any marked extent.

One subject, K, used the right hand exclusively in the first test, and in manipulating the forms at the right in the second test; however, in manipulating the forms at the left in that test he strongly favored the left hand; and in section 2 of test 3, he showed no marked preference for either hand.

Three subjects, F, N and R, representing 18.75% of the group, showed a marked preference for the left hand in section 2 of test 3, a section in which the twelve children named above favored the right hand primarily or exclusively. Subject N did not use the right hand alone in any trials in this section. In the manipulation of the forms at the right of the board, in test 2, these subjects all favored the right hand primarily; however, in test 1 and in the manipulation of the forms at the left of the board in test 2, they

differed in performance. In test 1, subjects F and R primarily favored the right hand, while subject N showed no preference for either hand. In manipulating the forms at the left of the board in test 2, subjects F and N each favored the left hand, whereas subject R used the right hand exclusively.

Subject S showed a marked favor for the use of the right hand in manipulating the forms at the left as well as those at the right in test 2, and in section 2 of test 3; however, in test 1 this subject showed no marked preference for either hand, using each hand in manipulating 50% of the marbles.

The series of ten daily observations of uncontrolled activities of these children, reported by the experimenter in the last section of this paper, gave no evidence of preferential use of the left hand (that is, in activities other than the picking up of objects under conditions favoring the use of the left hand) except in the case of subject F. This subject occasionally picked up the tiny boards containing colored pins from a box with the right hand, and holding the board in the right hand, he would remove the tiny pins from it with the left hand and place them in the beaver board with that hand. Subject S had used his left hand primarily the year previous to these experiments; however, according to the report of his parents, and observations of daily activities made by the experimenter, he was, at the time of this study, definitely right-handed in his habits.

Left-handed group

The per cent of choices made in favor of the left hand by each child in tests 1 and 2 respectively, and in section 2 of test 3, is shown in table 2. A single asterisk placed above the per cent of left hand choices in this table indicates that the remaining trials were performed by both hands functioning simultaneously; a double asterisk indicates that part of the remaining trials were performed by the right hand alone, and part by both hands simultaneously. Where no asterisk appears, and the left hand has not been used exclusively in 100% of the trials, the right hand was used alone in the remaining trials.

Analysis of table 2 indicates that, while none of the subjects in

this group used the left hand exclusively in all tests, the tendency of the majority was toward a pronounced preference for the left hand in all tests except that section of test 2 in which forms lying at the right of the board were manipulated. One subject, Ee, showed a strong bias for the left hand in all tests, including that section of test 2 in which the objects of manipulation were lying at the right of the board. Three subjects, Dd, Ff and Gg, representing 50 per cent of the group, showed a marked favor for the use of the left hand in all tests except in manipulating the forms at the right of the board in test 2, one of these subjects, Dd, using the right hand primarily in that section, and subjects Ff and Gg

TABLE 2

Left-handed group

Per cent of choices favoring the *left* hand in the respective tests

SUBJECT	AGE	TEST 1: MARBLE-BOARD	TEST 2: FORMBOARD		TEST 3: PICKING-UP-TOY
			Left side	Right side	
Dd	3′ 10″	80%	100%	30%	100 %
Ee	4′ 3″	85%	100%	70%	100 %
Ff	5′ 2″	92%	100%	45%	44.4%*
Gg	5′ 4″	92%	100%	45%	90 %*
Hh	6′ 2″	6%	100%	20%	10 %
Ii	6′ 5″	55%	100%	30%	90 %

showing no marked favor to either hand. Subject Ii showed a marked preference for the left hand in test 3, and in the manipulation of the forms at the left in test 2; however, she used the right hand to a marked degree in manipulating the forms at the right in test 2; and in test 1, she showed no marked favor to either hand. Subject Hh exhibited strong right hand preference in all tests except in the manipulation of the forms lying at the left of the formboard in test 2. In that section he used the left hand exclusively. This subject was reported by his parents as being left-handed. He had been attending kindergarten for a year prior to these experiments, and during that period had been participating in games with other children of his age.

Ambidextrous group

The per cent of choices favoring the hand used in the majority of trials in each of the three tests, is given below for each of the three subjects in this group:

SUBJECT	TEST 1 (MARBLEBOARD)	TEST 2 (FORMBOARD)		TEST 3 (PICKING-UP-TOY) SECTION 2
		Right side	Left side	
Cc	R 55%	R 100%	L 90%	R 56%
Jj	L 100%	R 60%	L 95%	B 90%
Kk	L 70%	R 90%	L 100%	L 78%

All three of these subjects favored the "convenient" hand, in test 2; although when the "convenient" hand was the left hand, the degree of bias was very pronounced on the part of all three subjects, whereas when the "convenient" hand was the right hand, that is, when the forms at the right of the board were manipulated, there was some variation in degree of bias shown by the three subjects. Subject Cc, who used the right hand exclusively in manipulating the forms at the right in test 2, and who used the left hand somewhat less than the other two subjects in manipulating the forms at the left in that test, favored the right hand slightly more than the left in tests 1 and 3 respectively. Subjects Jj and Kk both favored the left hand primarily in test 1, and in test 3 subject Kk favored the left hand to a marked degree while subject Jj used both hands simultaneously in the majority of trials.

An evaluation of the specific tests as suggested means of diagnosing "native" handedness

The results obtained in tests 1 and 2, and section 2 of test 3, were studied for the purpose of evaluating these tests as means of diagnosing so-called "native" handedness. As previously stated, the criterion of "native" handedness was the report of the parent as to the hand used in daily activities. This study included only the performances of the 13 children in the Right-handed group, 6 in the Left-handed group, and 2 in the Ambidextrous group, who

had completed tests 1 and 2, and section 2 of test 3. Thus, the performances of subjects B, C, D in the Right-handed group, subject Aa in the Left-handed group, and subject Cc in the Ambidextrous group, were not included in this analysis because each of them failed to complete one or more of the tests. For example, subjects B, C and Aa completed only one of the 4 trials in the

TABLE 3

A comparison of the degree of choice for the "preferred" hand manifested in each test

	TEST 1	TEST 2		TEST 3 SECTION 2
		Right side	Left side	
Right-handed group—13 subjects				
Number of subjects making 100% *right* hand choices	7	10	2	1
Number of subjects making 66.7% or more, *right* hand choices	11	13	5	8
Average per cent of *right* hand choices made by group	87.6%	94.2%	44.2%	58.1%
Average deviation	14.4%	8.9%	31.6%	25.7%
Left-handed group—6 subjects				
Number of subjects making 100% *left* hand choices	0	0	6	2
Number of subjects making 66.7% or more, *left* hand choices	4	1	6	4
Average per cent of *left* hand choices made by group	68.3%	40 %	100%	70.3%
Average deviation	25.2%	13.3%	0	32.5%

Formboard test; and subjects C, D, Aa and Cc did not complete the Marble Board Test.

The results obtained in sections 1 and 3, respectively, of the Picking-up-toy test are not included in this comparative study for the reason that, in section 1, the form of manipulation primarily favored was that of simultaneously reaching and grasping with both hands, each hand seizing one of the two desired objects; and in section 3, the number of trials given were too few to warrant generalizations being drawn therefrom.

Table 3 shows the following for each test: (1) the number of children in the Right-handed and in the Left-handed group, respectively, who showed consistent preference for the habitually "preferred" hand; (2) the number of children in each group who showed preference for the "preferred" hand in at least $66\frac{2}{3}\%$ of the total number of choices in a given test; (3) the average per cent of choices made by each group for the "preferred" hand; (4) the average deviation.

Analysis of the results shown in the Marble Board test, and those shown in the manipulation of the right and left sides, respectively, of the Formboard test, indicates that in both the Right-handed and the Left-handed groups, less individual variation and a higher degree of manual bias for the "preferred" hand is shown in the manipulation of the forms lying at the side of the Formboard corresponding to the "preferred" hand than is shown in test 1, or in the manipulation of the forms lying at the side of the Formboard opposite to that corresponding to the "preferred" hand—termed the "non-preferred" side—in test 2. In fact, there is uniformity of preferential manipulation of the forms at the "preferred" side of the board; for in the Right-handed group all of the children used the right hand to a pronounced degree, although but 10 of the 13 subjects used that hand exclusively; and in the Left-handed group, all six of the subjects favored the left hand exclusively in manipulating the forms at the left. The Marble Board test ranks second with respect to degree of manual bias for the "preferred" hand, as shown by the average per cent of choices for that hand made by each group, as well as by the number of children in each group who favored the "preferred" hand exclusively, or at least primarily. The lowest degree of manual bias for the "preferred" hand was shown by each group in manipulating the forms lying on the side of the Formboard opposite the habitually preferred hand. It will be noted that in the Left-handed group, the average deviation in the Marble Board test is somewhat higher than in that section of the Formboard in which the forms lying at the "non-preferred" right side were manipulated. Analysis of individual performances indicates that in the Marble Board test, subject Hh, who,

as before stated, had been attending kindergarten for a year prior to taking these tests, used the right hand in manipulating 94% of the marbles, while the remaining five children in this group strongly favored the left hand in that test. The performance of the two ambidextrous children was similar to that of the majority of the children in the Left-handed group, as both of these subjects showed a pronounced preference for the left hand in the first test, as well as in manipulating the forms at the left in the second test; whereas in the manipulation of the forms at the right in the second test, the right hand was favored primarily though not exclusively.

Thus, it appears that the factor of convenience plays an important part in the preferential manipulation of children in tests of the type given, and under the conditions presented. When objects were conveniently located with reference to the "preferred" hand, the tendency to use that hand was pronounced on the part of all of the children in both the Right-handed and Left-handed groups. When objects were equally accessible to either hand, the tendency toward the use of the "preferred" hand was likewise pronounced on the part of the majority of the children in both groups, although there were some individual variations. When objects were conveniently located with reference to the "non-preferred" hand but inconveniently located with reference to the "preferred" hand, considerable variation in degree of bias for the "preferred" hand was shown on the part of the subjects in both groups, a minority only favoring the "preferred" hand to a pronounced degree; as the remaining children varied from exclusive use of the "non-preferred" but convenient hand, to approximately equal degrees of choice for each hand.

If we assume that a test becomes an adequate measure of so-called "native" handedness in so far as the results of such a test agree with the "facts of the case" (as determined by reports of the parents as to the preferential manipulation exhibited by the child in daily activities); then, on the basis of the above data, we may assume that a test of the Formboard type, in which a convenience is offered to the use of the "preferred" hand, is an adequate test of "native" handedness, since the results of the Formboard test on the "preferred" side of the board (in which a

convenience is offered to the use of the preferred hand) show marked agreement with reported daily preferential handedness. And, if the degree of preference manifested for the preferred hand in a given test, ranging from 100% to zero, is indicative of *degree* of "native bias", then on the basis of the above data, a test such as the Formboard under conditions offering an *inconvenience* to the use of the preferred hand may be considered an adequate test of the "degree" of manual bias.

However, in as much as the purpose of a test of "native" handedness, and of degree of manual bias, is to ascertain these facts in cases where they are not known, rather than to confirm them according to some already accepted criterion, neither of these facts could be ascertained by a test which involved *one* of the situations only, that is, convenience *or* inconvenience to the use of the preferred hand. For example, if a group of children regarding whose manual bias nothing is known were to manipulate forms lying at the left of the board only, among the group who used the left hand consistently, or to a pronounced degree, would be, presumably, practically all of the children who were "natively" left-handed, as well as those children who, in daily activities, were primarily right-handed, but who used the left hand in activities of certain types when convenience dictated; that is to say, those children who were natively right-handed, but to a lesser degree than many others. And, in order to determine which of those children who used the left hand for the manipulation of forms lying at the left of the board were "natively" left-handed, and which were right-handed children of relatively low degree of bias, it would be necessary to introduce the opposite form of test, wherein the forms were placed at the right of the board, thus offering an inconvenience to the native left-handers, and a convenience to the right-handers. Then would be introduced another factor, precluding the determination of absolute types; for, in as much as among the left-handers as well as the right-handers, there were found some individuals who favored the "preferred" hand despite the inconvenience imposed, and others who favored the "non-preferred" but convenient hand; there would then result a group of children who favored the

"convenient" hand, using the right hand when objects were conveniently located with reference to it, using the left hand when that hand was so favored: a group of children among whom there were some who, in daily activities such as painting, drawing, and cutting with a scissor, consistently used the right hand; some who, in these activities, consistently used the left hand; and some who, in these activities, used the hands interchangeably. The assumption of *degrees* of manual bias, ranging from a pronounced degree of preference for either the right or the left hand, to an ambidextrous state where neither hand is favored, seems to fit the results found in all tests given in this study. And, a test of the type of the Formboard, given under conditions used in this study, wherein a number of objects were conveniently located with reference to the right hand, and the same number conveniently located with reference to the left hand (thus offering an inconvenience to whichever was the "preferred" hand in the manipulation of half of the forms), provides a method of ascertaining these *degrees* of manual bias, rather than ascertaining a division into definite "types".

In the Marble Board test, in which equal opportunity was offered for the use of either hand, while the number of children in each group who showed pronounced favor to the "preferred" hand was not quite as large as the number who showed a pronounced bias in manipulating the forms on the "preferred" side of the board in the Formboard test, nevertheless it was considerably larger than the number who showed a pronounced bias in manipulating the forms on the "non-preferred" side of the board in that test. It might be that the nature of manual choice under conditions offering equal opportunity for the use of either hand is diagnostically more significant in ascertaining manual bias than is the nature of choice when objects are conveniently located with reference to one hand, but inconveniently located with reference to the other, in as much as factors of convenience apparently predispose to the use of the "convenient" hand—practically exclusively when the convenient hand is also the preferred hand, and to varying extent when the convenient hand is the non-preferred hand. So that, in so far as it is possible to divide individuals into "native" right-handers, left-handers or ambidexters, the

Marble Board, or the Peg Board, or a test of similar type, given under conditions affording equal opportunity for the use of either hand, may be adequate. However, the author inclines to the view that such a test determines *trends* rather than definite types.

The average per cent of right hand choices made by the Right-handed group in the Picking-up-toy test was considerably less than in the Marble Board test, or in the manipulation of the forms at the right in the Formboard test; but was greater than in the manipulation of the forms at the left in the Formboard. In the Left-handed group, the average per cent of left hand choices made in the Picking-up-toy test was greater than in the manipulation of the forms at the right of the Formboard, and slightly greater than in the Marble Board test; but was considerably less than in the manipulation of the forms at the left in the Formboard.

Among the environmental factors noted which may have affected manual bias in this test was that of variation in position. According to the analysis made in section 2 of Test 3, of manual choice in relation to the position assumed by the child at the basket prior to reaching for and grasping the desired object, it seemed that, when the position assumed by the children in both the Right-handed and the Left-handed groups was at the side of the basket corresponding to the habitually preferred hand, there was a pronounced preference on the part of the majority of the children toward the use of that hand; when the position assumed at the basket was center, the preference for the "preferred" hand was likewise pronounced, but to a lesser degree than when convenience favored the preferred hand; and, when the position assumed by the child was at the side of the basket opposite to that corresponding to the preferred hand, there was a decrease in average per cent of choices for the preferred hand in both groups, neither hand being definitely favored. Individuals showed considerable variation, some consistently favoring the "preferred" hand though they stood in the "non-preferred" position, some favoring the non-preferred but convenient hand in that position, and some showing no definite preference for either hand. Thus, this test apparently confirms the results found in the Form-

board test and in the Marble Board test, namely: that, under conditions offering a convenience to the use of the preferred hand, there was a pronounced tendency toward the use of the preferred hand on the part of all of the children in both the Right-handed and the Left-handed groups; that under conditions offering equal opportunities for the use of either hand, the preferred hand was definitely favored by the majority of children in both groups; and that, under conditions offering an inconvenience to the use of the preferred hand, there was considerable variation in degree of manual bias for the habitually preferred hand.

While the results in these three positions assumed in section 2 of the Picking-up-toy test approximate the results in the Marble Board test and the Formboard test, where conditions of convenience are relatively the same, nevertheless the degree of manual bias shown in these three positions of section 2 of test 3 vary somewhat from the degree of bias shown in the Marble Board and the Formboard tests. This may be accounted for to some extent by the fact that in the Picking-up-toy test there were many environmental factors which may affect preferential manipulation which were not present in the Marble Board and Formboard tests. In the first place, in the latter named tests, the objects of manipulation were definitely located in *one* of the three following positions: (1) center, thus being equally accessible to either hand, (2) at the right, or (3) at the left. In section 2 of the Picking-up-toy test, the child himself assumed a position, (1) center, (2) to the right, (3) to the left, in relation to the basket and the desired object. However, as previously stated, the assumption by the child of a right or left position is not a two-positional affair, but may vary in, (1) degree of deviation to the right or left from a straight line approach to the object, and in (2) the angular incidence of the body in relation to the object grasped. Also, with reference to central position assumed by the child, as this designation is based entirely on the observation of the experimenter, it is possible that in some instances where a child is termed as having assumed a central position, his position might have been to the right or left, but to so slight an extent that it was impossible to discern by simple observation, though perhaps sufficient to influence the

child's performance, in so far as the positional factor operates in manual choice. Another factor to be considered in comparing the degree of preference for the "preferred" hand in the three positions in section 2 of the Picking-up-toy test with the degrees of bias exhibited in the Marble Board and the Formboard tests, is the fact that the object manipulated in the Picking-up-toy test was of a size which permitted the use of both hands simultaneously in seizing it, whereas the objects used in the Formboard and Marble Board tests were small, and readily grasped by one hand only. Thus, the possibility of three types of manipulation in the Picking-up-toy test reduced the per cent of right hand choices, as well as of left hand choices.

It seems, then, that a test of preferential manipulation in a situation involving rapid, spontaneous choice of hand, under conditions provided in this experiment, does not prove as adequate a test of so-called "native" handedness as does the Marble Board test, wherein equal opportunities were offered for the use of either hand by virtue of the position of the objects to be manipulated rather than by virtue of the position assumed by the child after running toward the object. It may be that environmental factors, such as position assumed by the child at the basket, or perhaps the final foot position of the subject just prior to reaching for and seizing the object desired, influences manual choice. It may also be that this specific activity is too closely related to those daily activites, like picking up an object which has dropped to the floor, picking up desired objects from the table, and so on—in which many children have formed the habit of using either hand, depending upon convenience and other environmental conditions—to warrant the use of a test of this type as diagnostic of so-called "native" handedness.

Summary of tests of handedness. In a series of manual tests given to a group of pre-school children for the purpose of ascertaining the preferential manipulation in motor activities of various types given under varying conditions, the following significant responses were noted:

1. Variability in the type of manipulation employed by the different subjects was shown in all three tests. In the Marble

Board test, while the method favored by the majority of children was unimanual, one hand picking and placing the marbles throughout the test, this method was varied by some of the subjects with one or more forms of the bimanual method. Bimanual manipulation assumed four forms in this test, in two of which the function of the two hands was the same in kind, and in two, the function of the two hands differed.

In the Formboard test, the method of manipulation was primarily unimanual, although occasionally a subject adopted a bimanual method of manipulation, one hand picking the form and passing it to the other hand to place.

In the section of the Picking-up-toy test in which 2 objects were employed, the method of manipulation was almost exclusively bimanual, each hand grasping an object simultaneously with the other. In the sections of this test in which one object was the stimulus for response, unimanual and bimanual methods of manipulation were employed, that is, the desired object was grasped by either the right hand or the left hand, or by both hands simultaneously.

2. The factor of convenience apparently plays an important part in the manual choice of young children in activities of certain types. In the Marble Board test, in which the objects of manipulation were equally accessible to either hand, a pronounced preference for the hand habitually used in daily activities, called the "preferred" hand, was noted on the part of the majority of the children in the Right-handed and the Left-handed groups. The two ambidextrous children who completed this test showed a marked left hand bias therein. Degrees of bias for the "preferred" hand ranged, in the Right-handed group, from the exclusive use of the right hand in manipulating all of the marbles, to a type of performance in which neither hand was shown any marked preference. Fifty per cent of the children in this group used their right hand exclusively. In the Left-handed group, degrees of bias ranged from the almost exclusive use of the left hand on the part of one subject, to the use of that hand in but few choices on the part of another subject.

In the Formboard test, when objects were conveniently placed

with reference to the "preferred" hand, a definite bias for that hand was shown by all of the children in the Right-handed and in the Left-handed groups. Consistency of use of the "preferred" hand in the manipulation of all of the forms in all trials of this test was shown by all of the children in the Left-handed group, and by approximately 84% of the children in the Right-handed group. Thus, under conditions offering a convenience to the use of the "preferred" hand, little evidence of degrees of bias was manifested.

When, however, objects were so placed in the Formboard test, as to offer an inconvenience to the use of the "preferred" hand but a convenience to the use of the "non-preferred" hand, variability in degree of preference for the "preferred" hand was evident in both the Right-handed and the Left-handed groups. In the Right-handed group, the range of preference for the right hand, despite the inconvenience offered, was from 100% to zero; in the Left-handed group, the range of preference for the left hand was from 70% to 30%. The children tended to fall into three groups, as follows: (1) those who, despite the inconvenience offered to the use of the "preferred" hand, nevertheless showed a pronounced tendency toward the use of that hand; (2) those who favored to a pronounced degree the "convenient" but "non-preferred" hand; (3) those who showed no marked degree of preference for either hand. In both the Right-handed and the Left-handed groups, division (2) was the largest.

Consistency in manual choice in manipulating the forms at the "non-preferred" side of the formboard—that is, the side opposite the hand habitually used in daily activities—in all four trials of this test was noted in the performance of 5 right-handed children, representing approximately 30% of the group. Three of these children used the right hand exclusively and two used the left hand exclusively, in manipulating the forms at the left in all trials. None of the left-handed children exhibited consistency in manual choice in all trials. When trials were considered separately, many children in each handedness group consistently favored a given hand in manipulating the five forms on the "non-preferred" side in a given trial.

The three ambidextrous children who completed this test all

favored the left hand to a marked degree in manipulating the forms at the left. In manipulating the forms at the right, all three favored the right hand primarily, although to varying degrees, ranging from 100% to 60%. Thus, the children in the ambidextrous group favored the hand which was more conveniently located with reference to the desired object to a greater extent than the hand not so favorably located; although, when the left hand was the convenient hand, the preference for it was marked to approximately the same extent by all of the children, whereas when the right hand was the convenient hand, there was some difference in degree of preference for it.

Various environmental factors were noted, in the Formboard test as well as in the Marble Board test, which may have influenced manual choice in specific cases, although none of these factors was found to invariably do so.

Only one of the five children in the two-year age group manipulated all of the marbles in the Marble Board test; and one manipulated half of the marbles. These two subjects both favored the right hand practically exclusively. The remaining three two-year olds apparently regarded the marbles as objects to roll, or pick up and let fall through the fingers, an activity in which both hands functioned. In the pegboard test, which was given to all of the two-year-olds as a substitute for the marble board test, the three right-handed children manifested a marked preference for the use of the right hand, and consistently favored this hand in three successive daily tests. The one ambidextrous child and the one left-handed child in this group varied in their manual bias on different days.

In the Picking-up-toy test, in which situations were imposed calling for rapid, spontaneous choice of hand, when two similar adjacent objects were to be secured, no preference was shown to either hand with reference to type of function, in any of the three handedness groups; nor was either hand favored to any extent in point of time as the method of manipulation primarily employed by practically all of the children was that of reaching for and grasping an object with each hand simultaneously. Thus, in situations where two objects of the same type, in proxim-

ity to each other, and equally accessible to either hand are to be secured, the young child apparently does not specialize in the use of the hands, using one exclusively to reach for the object, and the other to hold it; but the hands function primarily in unison, in the most efficient, convenient manner under the circumstance.

When a single object was to be secured in this test under conditions calling for rapid, spontaneous choice of hand, and where a straight line approach to the object from the starting point was rendered feasible, though not exclusive, the tendency toward the use of the "preferred" hand was pronounced on the part of the majority of the children in both the Right-handed and Left-handed groups, although there was individual variation, some children in each group manifesting a pronounced bias for the "non-preferred" hand under these conditions. Considerable variation was shown in degree of manual bias for the "preferred" hand in repeated trials, in both groups, as the use of the "preferred" hand in the total series of trials given over the three day period ranged from 100% to zero. Although comparatively few children in any of the groups were consistent in the use of a given hand in the total number of trials given over the three-day period, when each of the daily series was considered separately, it was noted that on each day the majority of the subjects were consistent in their manual choice in the three trials.

Among the factors noted which might have influenced manual choice in this test was that of the position assumed by the child with reference to the object, after running from the starting point. Considerable variation was noted in position assumed by the subjects at the basket, when reaching for and grasping the kitty cat, not only with reference to a center, right, or left position, but also with reference to the degree of deviation to the right or left, and the angular incidence of the body in relation to the object grasped. Analysis of preferential manipulation exhibited in the three observable positions, right, left and center, indicated that, (1) when the position assumed by the child at the basket, after running from the starting point, was on the side corresponding to the "preferred" hand, thus offering a convenience to the use of that hand, there was a pronounced tendency toward the use of

that hand in both the Right-handed and Left-handed groups; (2) when the position assumed by the child was center, thus offering equal opportunities for the use of either hand, there was likewise a tendency toward the use of the "preferred" hand in both groups, although in the Right-handed group this tendency was not as marked as when the position assumed was at the side corresponding to the "preferred" hand; (3) when the position assumed by the child at the basket was at the side opposite to that of the "preferred" hand, there was considerable variation, some children favoring the "preferred" hand primarily, some showing marked favor for the non-preferred hand, and some showing no marked preference for either hand.

When a single object was to be secured, under conditions calling for rapid, spontaneous choice of hand, and where approach to the basket in a straight line from the starting point was rendered the feasible method of approach, the majority of children in both the Right-handed and the Left-handed groups favored their "preferred" hand more frequently than the non-preferred, many of them using the preferred hand consistently in all three trials. However, the results in this three-trial series did not differ from the results in a given daily series of three trials in section 2 of this test, where approach to the basket to the right or left of a straight line from the starting point was not precluded, to any greater extent than did the results of any of the daily series in section 2 differ from the others.

3. No constant relationship appeared to exist between position assumed by the subject and manual "types", that is, right-handed or left-handed children; as relatively few children in either the Right-handed or Left-handed groups consistently maintained the same position in all trials of sections 1 and 2 of the Picking-up-toy test, or even in any single section. However, there was a marked tendency on the part of the majority of children in the Right-handed group, when running from the starting point to the basket in that section of the Picking-up-toy test in which one object was to be secured, to assume a position on the side corresponding to the "preferred" hand more frequently than at the left or center. In the Left-handed group, the majority of

the subjects favored center position primarily, although there was some individual variation. In that section of the test in which two objects, adjacent to each other, were employed as stimuli to reaction, center position was assumed more frequently than either right or left, by both the Right-handed and the Left-handed groups. In the Right-handed group, the right position was favored next in degree of frequency in this section; in the Left-handed group, the left position was next in favor.

4. Direction of orientation after the desired object or objects had been secured, in the Picking-up-toy test, was inversely related to the position assumed by the subject as he grasped the object. Thus, when the child stood at the right of the basket, direction of turn after the object had been seized was almost invariably toward the left; and when the position assumed was at the left of the basket, direction of turn was almost invariably toward the right. This was true of all three handedness groups.

When center position was assumed, there was some individual variation, although all three handedness groups showed a marked preference for the left turn.

5. No specific relation was found to exist between direction of orientation after the object had been secured and manual choice. This was studied in that section of the Picking-up-toy test in which the adoption of a center position was facilitated by the nature of the experimental conditions. In both the Right-handed and Left-handed groups, the children tended to fall into 3 groups with reference to direction of turn following manual choice, as follows: (1) those who consistently evidenced an inverse relationship between manual choice and direction of orientation, turning left after using the right hand, or turning right after using the left hand; (2) those who consistently evidenced a direct relationship between manual choice and direction of orientation; (3) those who varied between these two methods, showing a direct relationship in some trials and an inverse relationship in others. This last group was the largest of the three in both the Right-handed and Left-handed divisions. As all three of these tendencies were noted in both the Right-handed and Left-handed groups, no consistent relation could be assumed between direction of

orientation after the desired object had been secured and manual "types"—that is, the habitually right-handed or left-handed.

6. While none of the children in either the Right-handed or the Left-handed group used the "preferred" hand exclusively in all trials of all three handedness tests, the majority of the children in both groups showed a strong bias for their "preferred" hand in all tests given under all conditions, except in that section of the Formboard test in which an inconvenience was imposed on the use of the "preferred" hand. There was some individual variation, however, in that a few children in each group used their "preferred" hand primarly under all conditions, even when an inconvenience was imposed upon its use; and a few children used their "non-preferred" hand primarily, not only when an inconvenience was imposed upon the use of the "preferred" hand in the Formboard test, but also in section 2 of test 3 where this condition was not involved.

7. The results of these various tests of handedness seem to indicate the existence of "degrees" of manual bias, ranging from a pronounced preference for either the right hand or the left hand, to a relatively ambidextrous state where neither hand is definitely favored, or where the hand "convenient" under the circumstance is favored. The two manual types designated conventionally as "right-handed" and "left-handed" apparently indicate "trends" rather than two distinct classes, at least in so far as activities of the type used in these tests are concerned. Since factors of convenience apparently predispose to the use of the "convenient" hand—practically exclusively when the convenient hand is also the habitually preferred hand, and to varying extent when the convenient hand is the non-preferred hand—it might be that the nature of manual choice under conditions offering equal opportunity for the use of either hand, is diagnostically more significant in ascertaining these "trends" than is the nature of choice when objects are conveniently located with reference to the one hand but inconveniently located with reference to the other. If we assume that a test becomes an adequate measure of these native "trends" in so far as the results of the test agree with the "facts of the case", as determined by report of the parents,

then on the basis of the data given in this report we may assume that a test of the type of the marble board, given under conditions offering equal opportunity for the use of either hand as in this study, affords a means of ascertaining these "trends". Results obtained in this report indicate that the Picking-up-toy test, under the conditions given, is apparently less satisfactory for that purpose. A test of the type of the Formboard, given under conditions obtaining in this study wherein a convenience was offered to the use of the "preferred" hand in the manipulation of the forms lying on one side, but an inconvenience was offered to that hand in the manipulation of the forms lying on the other side of the board, seems to provide a method of ascertaining the "degree" of manual bias.

II. LEARNING SERIES

This study was conducted for the purpose of ascertaining whether the performance of the non-preferred hand improved with practice, and whether the performance of the preferred hand would show signs of improvement after the practice series by the non-preferred hand, suggesting transfer of training. Two learning series were given, one dealing primarily with the speed of learning, and the other with the accuracy of learning.

Series 1: Speed of learning

Twenty-seven pre-school children, ranging in age from 2 years 2 months, to 5 years 6 months, were the subjects. In the analysis of the data, however, the children were divided into two sections, due to the fact that the performance of some of the children did not lend itself to a study of learning effects for reasons which will be discussed later. There were 21 children, ranging in age from 2′ 11″ to 5′ 6″, in the section in which learning effects were studied. These children were divided into two groups, Right-handed and Left-handed, on the basis of their daily manual bias as reported by the parents, and by observers at the Child's Institute. In the Right-handed group there were 17 children, of whom 3 were five-year-olds, 6 were four-year-olds, 7 were three-year-olds, and one was a two-year-old within one month of her

third birthday. In the Left-handed group there were 4 children, of whom one was a five-year-old, one a four-year-old, and 2 were three-year-olds.

Apparatus and procedure. A wooden peg-board, approximately 12 inches square, and $\frac{7}{8}$ of an inch thick, containing 36 holes one-half inch in diameter, placed in six rows or columns of six each, equidistant from each other, was used. This board was painted in three colors of approximately equal intensity and brightness. One section, comprising one-third of the board and containing one-third of the holes, was blue; the second or middle section was orange; and the third section was green. A wooden knob was screwed into the side of the board, about midway, at the blue section. Thus, when the board was so placed that the knob was at the child's left, the colored sections from left to right were: blue, orange, green; and when the knob was at the child's right, the colored sections from left to right were: green, orange, blue. There were 36 pegs, each 3 inches in length and a little less than a quarter of an inch in diameter, which fit snugly into the holes. These were painted in colors corresponding to the sections of the board: 12 blue, 12 green, and 12 orange.

Each child was given a series of five trials with the non-preferred hand—that is, the hand not used habitually in unimanual activities nor in the major part of bimanual activities—and two trials with the habitually preferred hand. These trials were given daily over a five-day period in the following order:

17 RIGHT-HANDED CHILDREN			4 LEFT-HANDED CHILDREN		
Days	Trials		Days	Trials	
1	(1) R.H.	L.H.	1	(1) L.H.	(2) R.H.
2		L.H.	2		R.H.
3		L.H.	3		R.H.
4		L.H.	4		R.H.
5	(1) L.H.	(2) R.H.	5	(1) R.H.	(2) L.H.

Thus, each child in each group had five daily practice periods of one trial each with its non-preferred hand, this practice period being superseded and followed by one trial with the preferred hand.

The peg board was placed on a table approximately 21 inches high. The handle on the side of the peg board was toward the left when the right hand of the child was to manipulate the pegs, and toward the right when the left hand was to do the manipulating. A box the length of the peg board and about eight inches wide and two inches high, containing the colored pegs, was placed at the side of the peg board, opposite the side in which the handle was located, so that the pegs were within easy reach of the "active" hand, that is, the hand doing the manipulating. The pegs were well mixed in the box. The child was seated on a small chair before the table. Instructions were given as follows:

"Do you see this board and these pegs? I want you to put a peg into each of these holes as quickly as you can. Put one peg in at a time. Do you see these *blue* pegs (picking up one of the blue ones)? This peg looks just like this part of the board, doesn't it (holding the blue peg against the blue section)? Now, I want you to put all of the pegs that look just like this (indicating the blue peg) in this part of the board (indicating the blue section, and illustrate). And this *orange* peg looks like this part of the board, doesn't it (holding an orange peg against the orange section)? I want you to put all of the pegs that look just like this orange one in this part of the board (illustrating). And, this *green* peg looks just like this part of the board, doesn't it (holding a green peg against the green section)? I want you to put all of the pegs that look just like this green one in this part of the board (illustrating). (Then, removing the pegs from the board and putting them back into the box, continue):

"Now, I want you to hold on to the knob with *this* hand (indicating the "non-preferred" hand) and to put the pegs in the peg-board one at a time with *this* hand (indicating the "preferred" hand). When I say "Ready, go!", put them in as fast as you can. Ready! Go!"

The stop watch was started as soon as the child took up the first peg, and was stopped as soon as the last one was placed. On the first and fifth days, when each hand was given a trial, the pegs were removed from the board and placed back into the box by the experimenter, although at times the little subject insisted upon helping. The board was then reversed so that in the second trial on the first day the handle was on the side of the "preferred"

hand, and the box of pegs was on the side of the "non-preferred" hand. The experimenter placed the "preferred" hand of the child on the handle, instructing him that in this trial he was to hold the handle with that hand, and to place all of the pegs with the other hand, indicating the "non-preferred" hand. Instructions and illustrations were given again with reference to matching the pegs to the portion of the board correspondingly colored.

Record was taken by the observer of the following: (1) time, (2) errors in color matching (3) tendency to remove the "inactive" hand from the knob, or to maintain a constant hold, (4) tendency to aid with the "inactive" hand, (5) factors which might have influenced the child's performance on a given day. The data of chief interest in this study were those relating to the time taken in placing the pegs.

Results.—

Right-handed group

The daily average time scores made by this group, together with the average deviations, are as follows:

	FIRST DAY		SECOND DAY	THIRD DAY	FOURTH DAY	FIFTH DAY	
	Hand						
	R	L	L	L	L	L	R
Time	2′ 58″	3′ 18″	2′ 48″	2′ 34″	2′ 21″	2′ 21″	2′ 9″
A.D.	52″	46″	47″	35″	33″	31″	25″

A definite tendency was manifested by this group toward improvement in the performance of the left hand with practice. This improvement is noted not only with reference to the score made on the first day, but also with reference to each day's performance compared with that of the preceding day, with the exception of the last day, on which the score was the same as that made on the fourth day. The average time for the practiced left hand on the fifth day was 29% shorter than on the first day. Analysis of individual records indicates that, although only two

children in this group consistently showed an improvement in each day's performance with the left hand over that of the preceding day, all of the children with but one exception made better left hand scores on the fifth day than on the first day. One child showed a decline in performance of the left hand on the fifth day as compared with the first, although his performances on the second, third and fourth days respectively were better than on the first day.

An improvement was likewise noted in the unpracticed right hand on the fifth day compared with the first, the average time for the preferred hand after the practice series by the non-preferred hand being 27% shorter than on the first day, before the practice series by the left hand. Individual records indicate that with but one exception the children in this group all showed an improvement in the unpracticed right hand on the fifth day, after the practice series by the left hand. The subject who showed no improvement was somewhat petulant on this fifth day, and although she performed the first trial with good grace, she became sulky when told to put the pegs in another time, but with the right hand, saying as she worked "I've put them in once, that ought to be enough."

The average time scores for the group indicate that the right hand performance on the first day was superior to that of the left hand. This was also true on the last day, after the practice series by the left hand. Individual records indicate that 14 children in this group made a better score with the right hand than with the left on the first day, and three made a better score with the left hand than with the right, on that day. On the fifth day, 12 subjects made a better score with the unpracticed right hand than with the practiced left hand; 3 made a better score with the left hand than with the right; and 2 made the same score with each hand.

Many factors were noted which apparently affected the performance of a child and the resulting time score. Not infrequently, a child would stop in the midst of his performance, holding a peg above the board as he asked a question of the observer; and, in many cases, as the child worked, he would chat

about some matter of great interest to him—his little sister, his sore finger, the blue smock the observer was wearing, which was just the color of the blue pegs! Again, a child would stop for a few seconds on completing one colored section, and exclaim, "*Now* all the blue ones are finished!" clapping her hands in joy. Occasionally a child would remark, "I don't think I'll go fast to day; I want to go slow!" and would suit the action to the words. Weather conditions may have influenced performance to some extent. On a very warm day, one subject declared it was too hot to play, and manipulated her pegs in an obviously languid manner.

Relatively few of the children in this group made errors in color matching, particularly after the first day. In the majority of cases, these errors were noted by the subject himself, either immediately after placing the peg, or toward the end of the trial, when the child had two or three pegs of a given color left with no holes in the corresponding colored section in which to place them. Corrections were made in almost all cases with the hand "inactive" at the time, that is, the hand with which the child had been instructed to hold the knob. Errors were not restricted to a single age group, but occurred in all except age-group five; however, they occurred with greatest frequency in the three-year group. Only one three-year-old and the two-year-old approaching her third birthday, made errors in placement after the first day.

The three five-year-olds, five of the four-year-olds, and two of the three-year-olds held the "inactive" hand on the knob throughout each of the trials, except on a few occasions when that hand was used to correct a misplaced peg, or to steady the pegs in their recesses. One four-year-old, five three-year-olds, and the one two-year-old frequently removed the "inactive" hand from the knob on the first day, and occasionally on the second day, usually to correct a misplaced peg or to steady the pegs in the holes; and one of the three-year-olds persistently refused to keep the "inactive" hand on the knob, although she used it only to correct misplaced pegs.

Left-handed group

The daily average time scores for this group, together with the average deviations, are as follows:

	FIRST DAY		SECOND DAY	THIRD DAY	FOURTH DAY	FIFTH DAY	
	Hand						
	L	R	R	R	R	R	L
Time	3′ 18″	3′ 2″	2′ 51″	2′ 31″	2′ 48″	3′ 14″	3′ 24″
A.D.	1′ 19″	1′ 5″	18′ ″	43″	1′ 11″	1′ 48″	1′ 51″

According to the average scores for this group, there was a decline in the performance of the practiced right hand on the fifth day as compared with the first, although the scores for the second, third, and fourth days, respectively, were better than for the first day. There was likewise a decline in the unpracticed left hand on the fifth day, after the practice series by the right hand, as compared with the first day.

Analysis of individual records indicates considerable variation. Two children showed an improvement in the performance of the practiced right hand on the fifth day as compared with the first, one of these consistently improving each day over the performance of the preceding day. Two subjects made lower scores in the practiced right hand on the fifth day than on the first day. With reference to the performance of the unpracticed but "preferred" left hand; one subject showed an improvement and 2 subjects showed a decline in the performance of that hand on the fifth day compared with the first; and one subject had the same time record for the left hand on the fifth day as on the first.

The average right hand score for the group on the first day was better than the average left hand score. This was also true of the performances on the fifth day. Individual scores indicate that on the first day 3 subjects made better scores with the non-preferred right hand and 1 subject made a better score with the preferred left hand. On the fifth day, 3 subjects made better scores with the right hand than with the left, and one subject made the same score with each hand.

A few words may be said about the four subjects in this group, as follows:

Subject S was 4 years, 3 months of age at the time of this experiment, which was made one year ago. At that time he was termed left-handed by his parents. Throughout this current year, however, it has been noted through daily observation on the part of the experimenter that subject S now uses his right hand practically exclusively in unimanual acts like drawing, and in the active part of bimanual activities, such as cutting with a scissors, hammering, painting. His parents likewise report that he now favors his right hand. The records for this child in this learning series indicate a decline in performance in the practiced right hand on the fifth day compared with the first, although there was improvement on the second, third, and fourth days, respectively, over the first day's performance; and on the fifth day the same score was made by the unpracticed left hand as on the first day. The right hand performance on the first day was superior to that of the left; and on the fifth day, the time consumed in the trials was the same for each hand.

Subject Bb was 3 years old at the time of this experiment He was termed left-handed by his parents. In this peg-board experiment, not only was his fifth day performance with the practiced right hand inferior to that of the first, but in only one of the five practice periods with this hand did his performance show an improvement over that of the first day. His left hand performance on the fifth day likewise showed a decline over that of the first day. On both the first day and the fifth day, the right hand performance was better than that of the left. One of the difficulties encountered in endeavoring to note practice effects in activities of children through the time score was very evident in Bb's daily performance. Whenever he made an error, which he usually observed almost immediately, he would stop and glance shyly at the examiner to see if he were observed.

Subject Ff was 5 years 2 months of age at the time of this learning series. She was a pronounced left-hander, according to the statement of her mother and observations made by the experimenter of her daily activities at the Institute. She was definitely determined to use her left hand, and greatly resented any suggestion that she should use the right hand, saying defiantly, "My father said that I should use my left hand and *not* my right." Throughout the experiment she appeared exceedingly disinterested, and apparently used her right hand as directed because her mother had requested her to do as the experimenter desired.

Subject Ee was 3 years 11 months of age at the time of this experiment. According to the statement of his mother, and observations of his daily activities made by the observer at the Institute, he was decidedly left-handed. He was very much interested in the peg board and was very eager to work as speedily as possible, not resenting the necessity of using the right hand. His performance shows an improvement in the practiced right hand, not only on the fifth day as compared with the first, but on each successive day as compared with the preceding day. The left hand likewise showed considerable improvement on the fifth day as compared to the first, the time of manipulation being approximately 35 per cent less on the fifth day than on the first.

The three older children in this group made no errors in placement, but the three-year-old, Bb, made frequent errors. Sometimes they were noted by him immediately and corrected with the hand that was holding the knob; again they were not observed until the end of the trial, when there was a colored peg left with no place in the correspondingly colored section in which to put it. Frequently this subject would place the pegs incorrectly in an apparent spirit of mischief, glancing laughingly at the observer, and saying "See!" He would then remove it and place it correctly.

Two subjects, S and Bb, kept the inactive hand on the knob throughout the trials, although on the first day each of these subjects occasionally aided their performance with the inactive hand. Bb used the right hand to hold some of the pegs, as the left hand placed them, on the first day; and S, upon noting a misplaced peg, hastily adjusted it with the inactive hand. Ff did not maintain a firm grasp on the knob at any time, and frequently used the inactive hand to correct errors throughout the series of trials. Ee frequently removed his left hand from the knob on the first and second days when the right hand was doing the "active" part of the performance, and would reach over with his left hand and pick and place a peg occasionally. By the third day, however, he was holding firmly to the knob.

Six of the 27 subjects employed in this study ranged in age from 2 years 2 months, to 2 years 10 months. A learning series

was not conducted with this group, for the following reasons: (1) Although all of these subjects seemed to grasp the idea that the pegs were to be placed in a certain way, the nature of the placing—that is, the matching of the pegs to the part of the board corresponding in color—was comprehended by only two of these subjects. The remainder would place a green peg in the blue or yellow section, and glancing inquiringly at the observer, ask, "Dis go here?" (2) Of the two who apparently comprehended the nature of the task, one, a child of 2 years 7 months, was tested too late in the year to warrant a practice series. This subject, in the two trials made by him, made only a few errors in placing, and these he observed and corrected. He was attentive throughout the trials, was very much interested, and exceedingly swift, comparing favorably with the three and four-year-olds. The other subject, a child 2 years 10 months of age, although apparently comprehending the task, would soon weary of the color matching, and hilariously return to indiscriminate placing. It may be that the number of pegs to be placed rendered the task too long for the child's span of attention. After the daily instructions, he would place a dozen or so of the pegs correctly, glancing at the observer and saying "dis go here?", then he would become very playful and dance about in front of the table, placing the pegs on top of one another. (3) The concept of speed apparently has little meaning to many children at this age. The child below three years of age plays a great deal, claps his hands after putting in a peg, experiments by putting pegs on top of other ones before finally placing them, makes "funny" faces while working, or glances shyly at the experimenter as he fumbles with the pegs.

Series 2: Accuracy in learning

Five children, ranging in age from 4 years 4 months, to 5 years 5 months, were the subjects. Four of the children were right-handed and one was left-handed.

Apparatus and procedure. The activity chosen was that of throwing a solid rubber ball, 2 inches in diameter, through a steel hoop, 7 inches in diameter, into a bag of muslin fitted securely around the hoop. The hoop was firmly secured at the top and

bottom by means of snappers fastened to the upper and lower arms of an upright iron rod, which was approximately 5 feet in height. The muslin bag was held at the center by another snapper, suspended by means of a rubber band from the iron rod about midway between the two arms. This prevented the bag from dropping below the steel hoop, and formed a cornucopia into which the ball fell when it went through the hoop. As the arms, or horizontal bars, were movable, it was possible to adjust the hoop to the height of the child, so that when the arm of the subject was extended straight forward from the shoulder, it was in line with the center of the muslin bag. Each time the ball went through the hoop into the bag it was counted a success, regardless of whether it stayed in the bag or rolled out, as the object was to throw the ball *through* the hoop, and the bag was attached merely as a means of preventing the ball from striking against the wall.

A line was drawn with yellow chalk on the floor, three feet three inches from the hoop. The child was instructed to stand on this line when he threw the ball. It was estimated that when the child's hand was raised in position to throw the ball, the hand would be about 3 feet from the hoop.

Each child was given 125 trials with the non-preferred hand and 50 trials with the preferred hand. These trials were given daily over a five-day period, in the following order:

4 RIGHT-HANDED CHILDREN			LEFT-HANDED CHILD		
Days	Trials		Days	Trials	
1	(1) 25 R.H.	(2) 25 L.H.	1	(1) 25 L.H.	(2) 25 R.H.
2		25 L.H.	2		25 R.H.
3		25 L.H.	3		25 R.H.
4		25 L.H.	4		25 R.H.
5	(1) 25 L.H.	(2) 25 R.H.	5	(1) 25 R.H.	(2) 25 L.H.

Thus, each child had five practice periods of 25 throws each with its non-preferred hand, this practice period being superseded and followed by one trial of 25 throws with the preferred hand.

Instructions were given as follows:

"I want you to stand on this yellow line on the floor, and

throw the ball through the hoop into the bag with this hand (indicating the hand by placing the ball in the subject's "preferred" hand). You are going to have twenty-five trials, and we want to see how many times you can get the ball to go right through the hoop into the bag."

On the first day, after the first trial of twenty-five throws with the preferred hand, the ball was placed in the child's non-preferred hand, with the instruction that he was now to have twenty-five throws with that hand. Each day the ball was placed by the observer in the hand which was to do the throwing, with the instruction, "we are going to use *this* hand today."

Results. The daily scores, indicating the number of correct throws made in each series of 25 trials by each child in the Right handed group, is given below:

SUBJECT	FIRST DAY		SECOND DAY	THIRD DAY	FOURTH DAY	FIFTH DAY	
	Hand						
	R	L	L	L	L	L	R
N	7	6	2	4	4	2	3
R	9	12	8	5	6	9	13
S	8	8	11	12	11	15	11
U	10	10	6	4	9	14	18

Little evidence of improvement with practice in the performance of the non-preferred hand, over the five-day period, was given by any of the children in this group. Two subjects, N and R, made their highest score in the practiced left hand on the first day, showing no tendency to improve with practice. Subject N also showed a decline in the performance of his unpracticed right hand on the fifth day as compared with the first, while subject R showed some improvement in his hand. Two subjects, S and U, made better scores with the left hand on the fifth day than on the first; however, on the second, third, and fourth days, respectively, U made lower scores than on the first day, while S showed some improvement. Both S and U made better scores in their unpracticed right hand on the fifth day than on the first day.

The daily scores of the left-handed subject, Ee, are as follows:

FIRST DAY		SECOND DAY	THIRD DAY	FOURTH DAY	FIFTH DAY	
Hand						
L	R	R	R	R	R	L
7	9	10	9	8	12	15

While this subject showed an improvement in the practiced right hand on the fifth day compared with the first, little improvement was shown on the intervening days. The greatest extent of improvement occured in the unpracticed but "preferred" left hand on the fifth day compared with the first.

None of the four right-handed children showed a tendency to use the right hand to throw the ball during the left-hand series. The left handed child, however, would frequently transfer the ball from the right hand to the left hand, just as he was about to throw. He made no objection when the observer instructed him to use the other hand, and laughingly complied. Apparently he was not wilfully disregarding instructions, but the tendency to use the left hand in throwing may have been so strongly established that it was difficult to inhibit.

Summary. A practice series given to a group of pre-school children in the use of the "non-preferred" hand, preceded and followed by one trial with the "preferred" hand, in the placing of colored pegs within the sections of a peg board of corresponding colors, indicated the following significant responses:

1. In the Right-handed group, a marked tendency was shown toward improvement with practice in the performance of the "non-preferred" left hand. Improvement was also noted in the performance of the unpracticed right hand on the last day of the test, following the practice series by the left hand, as compared with the performance of the right hand on the first day, suggestive of transfer of training. The majority of the subjects in this group made better scores with the right hand than with the left hand on the first day of the test, as well as on the last day, after the practice series by the left hand.

2. In the Left-handed group, average daily scores indicated an improvement in the practiced right hand on the second, third, and fourth days, respectively, as compared with the first day; however the performance on the fifth day fell below that of the first. Individual records showed considerable deviation from group averages. One child showed a marked improvement daily in the practiced right hand over the score of the preceding day; two children showed some slight improvement in practice, although they varied from day to day; and one child showed no tendency toward improvement in the right hand performance with practice. The average scores for the unpracticed left hand on the fifth day as compared with the first showed no improvement in that hand; however, individual performances showed variation in this respect.

3. Various conditions were noted which might have influenced the daily variations in performance: (1) the mood of the child, brought about presumably by weather conditions, or physical conditions; (2) deviation of the child's attention from the situation in hand to some matter of interest to him, brought about by environmental features, or the general trend of his thoughts; (3) disregard of the time element through keen enjoyment in his production, expressed in actions and words which consumed time.

4. This test proved inadequate, on the whole, as a learning series for children under three years of age, for the following reasons: (1) lack of comprehension of the nature of the task, namely, the matching of the colored pegs to the correspondingly colored sections of the board; (2) the span of attention of children below the age of three apparently did not warrant the completion of a test of the length given, under the imposed condition of color matching; (3) the concept of speed apparently has no meaning to children below the age of three years. These are suggested reasons, only, as the number of children tested under the age of three years was not sufficiently large to warrant the drawing of conclusions.

A practice series given to four right-handed children and one left-handed child of pre-school age in throwing a solid rubber

ball through a steel hoop at a distance of three feet, indicated variation in performance. Three of the right-handed children showed little indication of improvement in the practiced left hand; and one of the right-handed children and the left-handed child showed some improvement in their practiced "non-preferred" hand, although this improvement was not pronounced in either case. With the exception of one right-handed child, all of the subjects improved in their unpracticed "preferred" hand on the last day compared with the first day.

III. TRAINING LEFT-HANDED CHILDREN IN THE USE OF THE RIGHT HAND

This study is concerned with the development of a method of training two left-handed children in the use of the right hand. Two practice series in motor activities of different types were given, one type involving the finer muscle coördinations, and one involving the gross muscle coördinations. The following conditions were observed by the experimenter in each test series:

(1) Bimanual activities were used of the type in which there was a major, active function, and a minor, accessory function. By this means the left hand was kept occupied in order to offer a relief for any tension which might be present due to the inhibition of the impulse to use the habitually preferred hand.

(2) Activities were chosen which were relatively new to the child in order to prevent, in so far as was possible, conflict with reactions which had become fixed.

(3) The endeavor was made to permit no suggestion to creep in that it was possible to use the left hand for the major part of the activity. When, despite this endeavor, a subject took the object of manipulation in his left hand, the experimenter transferred it back to the right hand as quickly as possible, in order to prevent the tendency to use the left hand from developing into explicit action. This transfer was also made as quietly as possible, in order to guard against emotional disturbance on the part of the child.

(4) Attempts were made to retain the interest of the child through various features of the test, and through competition with another child.

Two subjects were used. One subject, Ff, was a girl, five years old; the other, Ee was a boy, 4 years 3 months of age. Both children were decidedly left-handed, according to the statement of the parents, and the observations made by the experimenter of their preferential manipulation in daily activities engaged in at the Institute.

First test series

Procedure and apparatus. The Johnson Coördination test was used in this practice series, which involved the minute muscle coördinations. The form used is illustrated in Johnson (11). Two trials were given daily over a period of ten days or more. The right hand traced the path through the maze, while the left hand held a hard rubber ball, resting upon the table.[2] The paper was fastened by means of thumb tacks to a large board which was placed upon the table. A metronome, placed on the table before the child, was timed at 60 beats per minute.

Instructions were given as follows: "You are to draw a line in the path between these black lines, making a stroke with your pencil each time this clock ticks (illustrate by making a stroke of the pencil in a given segment to the beat of the metronome). Be careful not to touch the black lines with your pencil." The pencil was placed by the experimenter in the right hand of the child, and the ball was placed in the left hand.

This test, and the dart throwing test next discussed, were given during the same period, the coördination test first, and then the dart throwing test. Both children were so interested in the dart throwing test that they frequently requested permission to go to the experimental room "to hit the bull's eye" immediately upon sight of the experimenter. The coördination test, however,

[2] A more adequate means of relief for possible tension in the left hand might be provided in this test, if the rôle performed by the relatively unoccupied left hand were more closely related to that performed by the active right hand. If, for example, the coördination blank were clamped to a board which was itself securely fastened in order to prevent slipping, and if the child were required to hold the clamp—a fairly good sized one so that it could be grasped in the hand—with the left hand, as he traced the pathway with the pencil held in the right hand, this might be an improvement over the method used in this investigation.

was not popular with either child. As a means of securing the interest of the little subject, crayon pencils of different colors were used, and the child was permitted to choose the color he desired. Toward the end of the series of tests, the element of competitition with one of the children at the Institute in whom the subject was interested was used as a means of reviving interest in the tests.

Results. The number of contacts made by each subject in each daily test is as follows:

SUBJECT EE				SUBJECT FF			
Day	First trial	Second trial	Average	Day	First trial	Second trial	Average
1	9	—	9	1	11	—	11
2	8	11	9.5	2	9	15	12
3	9	12	10.5	3	9	6	7.5
4	14	11	12.5	4	12	—	12
5	15	14	14.5	5	8	10	9
6	15	16	15.5	6	7	12	9.5
7	8	12	10				
8	11	9	10				
9	12	6	9				
10	9	8	8.5				
11	3	4	3.5				
12	3	4	3.5				
13	3	6	4.5				
14	4	6	5				
15	3	2	2.5				

Subject Ee

The average number of contacts made by this subject daily in the two trials tends to increase from the first to the sixth day. Thereafter, he improved steadily, although on the 13th and 14th days respectively he made a few more contacts than on the 11th and 12th days, respectively.

Ee was usually very willing to come with the experimenter and to do as instructed. Toward the ninth day, however, he was apparently losing interest, so on the eleventh day the element of competition was introduced and continued throughout the remainder of this series. It will be noted that his performance on

the eleventh day, and on subsequent days, showed great improvement over his daily performances prior to the introduction of competition. On the sixteenth day he was very reluctant to perform the test, and in the midst of the first sheet, he suddenly jumped from his chair and darted from the room. No further trials were given.

This subject rarely objected to the use of the right hand, although during the first four or five days, he frequently complained that "using this hand makes me tired." On the first day one trial only was given, due to the obvious discomfort he was experiencing; and the experimenter thought it unwise to run the risk of antagonizing him against the test.

Considerable tension in the left hand, as well as in the face, was exhibited by this child on the first three or four days. The left hand quivered decidedly as he wrote, and the bright sunny smile gave way to contorted lips and lowered brows, as he laboriously traced a very irregular line through the pathways. He apparently made a strenuous effort to keep within the path and to avoid touching the heavy black lines bounding it. After the fourth day, practically no tenson was noted by the observer in Ee's left hand, nor was any evidence of discomfort manifested in his countenance.

During the early part of the practice series, when the pencil was handed to this subject, he would occasionally put down the ball which he was holding in the left hand, and hold out the left hand for the pencil. On several occasions, also, in the early trials, when the signal was given to start, he would release the ball and swiftly transfer the pencil from his right hand to his left hand. However, when the pencil was again placed by the experimenter in the right hand, and the ball in the left hand, with instructions to hold firmly to the ball, he made no remonstrance.

On the first two days, Ee started at the right of the paper and traced the path toward the left—the reverse of the usual right-hand method. For several days thereafter, the observer would point to the starting place at the left of the paper when the subject traced the first and second paths of the first sheet, but would let the child follow his own initiative in the remaining paths.

After the fourth day, he traced all paths from left to right, without suggestion from the experimenter.

Subject Ff

This subject made but little improvement with practice in the comparatively few trials given. Analysis of the performance of subject Ee during a comparable period indicates that Ee likewise showed no improvement during the first six days; in fact, he made more errors in average score on each of those days than on the first day. As Ff left the Institute after the sixth day of testing, she was not available for further experimentation.

Ff intensely disliked the coördination test and was averse to taking it. She was always eager to accompany the experimenter, as she was fond of the dart throwing test, given during the same period as the coördination test; but she submitted with ill grace to the coördination test. She was decidedly antagonistic to the use of the right hand in this test. On the first day, when the pencil was placed in her right hand, she turned belligerently to the observer, stating, "I'm not going to use my right hand; I can do it better with my left hand, and my father said I should use my left hand." Throughout the test she cast defiant glances at the observer, and finally announced, "I'm not coming to this school tomorrow; not if you make me use my right hand." One trial only was given on the first day, and a day or two elapsed before the experimenter again gave Ff the coördination test. On that day, although she made no remonstrance against using the right hand, she gave marked evidence of indifference, apparently making no effort to avoid striking the black lines bounding the path, and announcing when she had finished: "If you would let me do that with my left hand, I could do it much better." On the third day, Ff came to the experimenter and volunteered to "draw a path" for her. On the fourth day, after finishing one sheet she announced that she did not want to do any more that day. Ff seemed to waver between two influences: on the one hand, her father was apparently urging her to continue in the use of her left hand; while on the other hand, her mother was urging the child to do as the experimenter directed. The mother was desirous of

having the child use her right hand, whereas the father was apparently antagonistic thereto; in fact, on one occasion he stated to the observer that "she came by it naturally; her grandfather was left-handed."

Ff showed no discernible evidence of tension in the relatively inactive left hand, or in the face. Her performance throughout was apparently an indifferent one. Although she remonstrated against the use of the left hand, she exhibited no tendency to transfer the pencil to the left hand for use after the experimenter had placed it in the right hand. She always started at the left of the paper, and traced toward the right, in accordance with the usual right-hand method.

Second test series

Procedure and apparatus. A target board and darts were used in this practice series, which involved primarily gross motor coördination. The target board was the one used by Bates (2). The darts were the same as those used by Johnson (10). The board was adjusted to the height of the child and this adjustment was such that when the arm of the subject was extended straight forward from the right shoulder, it was in line with the bull's eye. A cross mark in yellow chalk was made on the floor 7 feet from the target board, and the child was instructed to stand at that place while throwing the darts. Each day, for a period of 10 days in the case of subject Ff and 15 days in the case of subject Ee, the child was given thirty darts to throw with his right hand, in three trials of ten throws each. The observer competed with the child in the early part of the series, observer and subject each throwing ten darts alternately. Later, a child friendly with the subject was used as competitor. The darts were held in the left hand of the subject and were thrown, one at a time, with the right hand. In order to avoid any suggestion that the left hand could be used for the active part of this test, the darts were always placed by the observer in the child's left hand, and instructions were given as follows: "Now, we hold the darts in this hand (indicating the left hand) and throw them one at a time with this hand (indicating the right hand). Stand on this yellow cross mark (indi-

cating the mark on the floor) and try to hit the bull's eye (indicating it)." If the subject transferred the darts, prior to throwing, to the right hand to hold and endeavored to secure one with the left hand to throw, the experimenter would quickly but quietly remove the darts from the right hand and transfer them again to the left hand, saying, "we *hold* them in *this* hand and throw them with *this* hand (indicating the right hand); that is the way the game is played."

Results. The daily scores made by each subject are given below:

SUBJECT EE		SUBJECT FF	
Day	Score	Day	Score
1	6	1	22
2	8	2	33
3	12	3	37
4	10	4	30
5	18	5	33
6	34	6	23
7	36	7	33
8	40	8	29
9	43	9	34
10	66	10	67
11	84		
12	75		
13	50		
14	61		
15	56		

Subject Ee

This subject showed a marked improvement daily, from the first day through the eleventh day, with the exception of the fourth day when the score dropped somewhat below that of the third day. The score made on the twelfth day was somewhat lower than that made on the eleventh day; and the scores made on the thirteenth, fourteenth, and fifteenth days respectively were somewhat lower than those made on any one of the three days preceding the thirteenth; however, on each of the four last days the score was considerably higher than on any day prior to the

tenth. A child of whom the subject was very fond was used as a competitor on the tenth day and on all days following.

On the first five days this subject would occasionally transfer the darts which he held in his left hand to the right hand, and would select one of them with the left hand preparatory to throwing with that hand. This occurred again on the eighth day, but ceased thereafter. On the first few days, also, when the last dart of a series fell to the floor instead of hitting and sticking to the target board, this subject would pick up the dart with the left hand and swiftly throw it.

Subject Ff

While this subject showed some improvement in score with practice, in that the score of each day was higher than that of the first day, her performance did not show the steady daily improvement that was evident in the performance of subject Ee, but varied considerably from day to day. An increase was noted on the second and third days respectively over the score of the preceding day; however, the daily scores on subsequent days all fell below that of the third day, until the tenth day was reached, when there was a significant increase in score. On that day the element of competition with another child was introduced. As subject Ff left the Institute at this time, it was impossible to continue this learning series further.

A comparison between the performance of subject Ee and that of subject Ff indicates that, while Ff made a score on the first day which was approximately four times that made by subject Ee on that day, on the tenth day the scores of the two subjects were equal. The score made by subject Ee on the tenth day was eleven times that made by him on the first day, while the score made by Ff on the tenth day was but three times her first day's score.

Throughout the test series Ff was intensely interested and did not manifest any objection to the use of the right hand as she did in the coördination test. It may be that her reluctance to use the right hand in the coördination test was partly due to the fact that the left hand had been habitually used in activities somewhat

similar in type, such as drawing, scribbling, painting; whereas, in the dart throwing test she was engaged in a practically new activity in which the impulse to use the left hand was not so strongly established. It may also be that the nature of the tests —one involving the finer muscle coördinations, the other the grosser—entered into the situation.

On no occasion did Ff transfer the darts from the left hand to the right hand to hold, in order to throw with the left hand. Occasionally, however, if the last dart thrown fell to the floor, she would pick it up with the left hand and attempt to throw it.

Summary. Training of two strongly left-handed children of pre-school age, in the use of the right hand in motor activities involving gross muscle coördination as well as those involving the finer muscle coördinations, seemed possible. Individual differences were noted with respect to extent of learning, attitude toward the use of the "non-preferred" right hand, and presence or absence of observable tension in the relatively unoccupied left hand and in the face during the test involving the finer muscle coördinations. The subject who showed marked improvement in his right hand performance in both tests had made no objection to the use of that hand. In the early stages of the test series involving the finer muscle coördinations, this subject evidenced strong tension in the left hand and in the face; however, this tension apparently disappeared after a few days of testing.

Improvement was manifested earlier in the dart throwing test, which involved primarily the gross motor coördinations, than in the "coördination test", which involved the finer motor coördinations.

Both subjects occasionally transferred the dart to the left hand for use in the dart throwing test, and one subject occasionally transferred the pencil to the left hand for use during the early part of the "coördination" test; however, this tendency toward the transfer of the object of manipulation to the preferred hand was eventually subordinated.

Improvement was noted in the performance of each of these subjects when competing with another child.

IV. DAILY OBSERVATIONS

Ten daily observations of ten minutes each were made by the experimenter on 21 children, ranging in age from 2 years 4 months to 5 years, for the purpose of ascertaining the preferential use of the hands and the consistency of such preference in daily activities of the child's own choice. These children fell into three groups on the basis of their age, as follows: (a) Two-year-olds, consisting of 4 children ranging in age from 2 years 4 months to 2 years 9 months. Three of these children were reported by their parents as being right-handed, and one as being left-handed in some activities, such as writing, eating, cutting with scissors, and right-handed in others. (b) Three-year olds, consisting of 6 children ranging in age from 3 years 2 months to 3 years 9 months. These children were all reported by their parents as being right-handed. (c) Four-year-olds, consisting of 11 children, ranging in age from 4 years to 5 years. Of this group, 7 were termed right-handed by their parents, 2 were termed exclusively left-handed, and two were termed ambidextrous, in the sense of using either hand for any given activity. These three groups carried on their activities in separate rooms of the Institute, one group being on each of the three floors of the building. For purposes of analysis, these children were divided by the observer into three handedness groups, namely, Right-handed, Left-handed, and Ambidextrous. Thus, in the Right-handed group there were 16 subjects, in the Left-handed group there were 2 subjects, and in the Ambidextrous group there were 3 subjects. Where age differences were shown with respect to type of activity indulged in, or type of manipulation employed, such differences were noted.

Method. The observer entered the room of a given age-group each morning at approximately the same time. Seating herself in the vicinity of the first child to be observed, she would spend some time in writing, without paying attention to any of the children, before beginning her observation. The reaction on the part of the children toward her presence was different in the three groups. In age-group two, shyness was occasionally manifested

when the experimenter entered the room. The children would stop in their activities and glance shyly at her; or, as in the case of subject Cc, would immediately attempt to claim her attention. This same attitude was directed toward other adults when they entered the room. After a few minutes the children would seem again at ease; and after a few daily visits to the group, there was nothing more than a shy glance or a smile directed toward the observer when she entered. The children in age-group three paid little or no attention to the observer. They were usually hilariously intent upon their own activities, and upon each other. In age-group four the observer was usually greeted by several of the children. She would respond with a "good-morning" and then return to her notebook activities. The children in this group gave no apparent evidence of embarrassment at the presence of the observer, nor did they seem aware that they were being observed.

Each day the experimenter took notes in shorthand of the activities of five or six children, observing each of them singly for a ten-minute period. Note was taken of: (1) the activities indulged in, (2) the hand used in unimanual operations, (3) the hand doing the major or "active" part of bimanual tasks, (4) conditions which might be contributory to the use of a given hand. This material was then organized so that a list was made for each child of the different activities indulged in, the number of times each activity was noted during the ten periods, and whether the use of the hands in a given activity was consistent throughout.

An attempt was made to classify the various activities observed into unimanual and bimanual types. One runs into difficulties here, for in many cases an activity which is in itself unimanual is attended by contributory activities making up a total situation. For example, while painting and drawing are unimanual activities in that one hand only manipulates the brush or pencil, yet the child usually engages his relatively unoccupied hand in an activity contributory to the main activity. He may hold the paint brush or crayon in the right hand as he wields it back and forth, and hold the left hand on the paper, perhaps steadying it. He may hold the paper in the left hand, as he manipulates the scissors with the right hand; or hold the nail with one hand as the other

hand strikes with the hammer. In other cases, an activity may be unimanual at times and bimanual at other times. The peg board, for example, may be an entirely unimanual activity, in that the child picks up and places the pegs with one hand throughout; or it may be bimanual in that one hand picks up the pegs and the other hand places them; or one hand may pick them up, pass them to the other hand to hold, and the first hand then takes them one by one from the second hand and places them. Carrying a cup of milk, or lifting it to the mouth, may likewise be unimanual or bimanual; although in this case, the nature of the bimanual activity is apparently somewhat different from that of the peg-board activity, in that the two hands coöperate in performing the same *type* of function—namely, steading the cup; whereas in the peg-board activity mentioned above the function of the two hands differs. The manipulation of plasticine, although bimanual in nature, may be different in form: for example, it may be moulded by the two hands coöperating in the some function, each of them kneading, moulding, forming, although perhaps in varying degrees; or it may be performed as an activity in which one hand has an active rôle, and the other hand a relatively passive rôle, as when the child holds the plasticine on the work table with one hand, and cuts off pieces of it with a tiny stick held in the other hand, or punches holes into it with a file held in the other hand. From one point of view the performance of each hand may be treated as a separate act; whereas from another point of view, the function of each hand may be treated as a part of a total activity making up a total situation. This latter is the point of view adopted in this paper. In the case of painting, drawing, cutting with scissors, where both hands are involved, one in the performance of a major task, the other in an accessory task, the two hands function simultaneously in the total situation or activity. In the case of the peg board, under conditions when one hand is engaged in picking the pegs, and the other in placing them, the hands function not simultaneously, but successively, and both activities are included in the total situation.

The forms of manipulation, then, have been classified as follows:

1. Unimanual acts: those which involve the use of one hand only. The "inactive" hand may be aiding in the performance of the task in so far as, in any integrated activity, the whole organism functions; however, it is not observable that the extent of aid given by the "inactive" hand is greater than that rendered by any other part of the organism.

2. Bimanual-1 acts: those in which both hands coöperate either sequentially or simultaneously to effect the completion of a total situation. In this particular type of activity, one hand assumes a major function, while the other hand assumes an accessory function, with each function differing from the other in kind and degree.

3. Bimanual-2 acts: those involving the coöperation of both hands and in which the function of the two hands is the same in kind, though perhaps not in degree.

The activities observed are listed below, under the three forms of manipulation noted above. Where an activity was performed in more than one way, it is listed under each of the respective headings.

I. Unimanual acts

(1) Picking up objects
(2) Carrying objects
(3) Serving milk and crackers
(4) Handing objects to others
(5) Accepting objects from others
(6) Wiping the table, floor, or blackboard
(7) Pulling a wagon
(8) Lifting a cup of milk to the mouth
(9) Lifting a cracker to the mouth
(10) Drawing with chalk on the blackboard
(11) Peg board
(12) Block building
(13) Ball throwing

II. Bimanual-1 acts

(14) Drawing with crayon on paper
(15) Writing
(16) Painting
(17) Brushing over cubes of paint
(18) Swirling a brush about in a jar of water
(19) Stamping numbers on paper with a rubber stamp

(20) Cutting out pictures, numbers, or designs, with scissors
(21) Brushing over cut-outs with a paste brush, and fastening them to a cardboard or other background
(22) Plasticine, used as an object worked upon by another tool
(23) Sandpapering blocks, or other wooden objects
(24) Manipulating implements, such as a saw, hammer, chisel, vise, screw driver
(25) Placing pins with colored celluloid tops in a beaver board
(26) Pinning a picture to burlap stretched against the wall
(27) Peg board
(28) Playing with blocks
(29) Stringing beads

III. Bimanual-2 acts

(30) Carrying objects
(31) Lifting a cup of milk, or cracker, to the mouth
(32) Serving milk, or crackers
(33) Moulding plasticine
(34) Sweeping.

Table 4 shows the frequency with which each child performed the various activities during the ten observation periods.

Results.—

Right-handed group

I. Unimanual acts. When unimanual acts such as picking up and carrying desired objects, picking up objects which have fallen, handing articles to or accepting them from others, picking up a cloth and wiping the table, floor or blackboard: when such acts were performed under conditions in which both hands were unoccupied and the object was equally accessible to either hand, the right hand was favored practically always by the children in all three age-groups. When, however, factors of convenience were involved, manual choice was apparently affected accordingly. Thus, when the child went to the shelf or table for a paint brush and paper, he would usually reach for one of these with the right hand. On some occasions, the child would carry this to his work table, and return for the second article, which he would usually secure with the right hand. As a rule, however, the child would, after securing the paint brush or the paper with the right hand, reach for the second object with the unoccupied left hand, particularly if the second object were in proximity to the

TABLE 4

Frequency of performance by each child of the various activities

ACTIVITY	RIGHT-HANDED GROUP															LEFT-HANDED GROUP		AMBIDEXTROUS GROUP			TOTAL FOR GROUP
	Two-year group			Three-year group						Four-five-year group								Four-five-year group		Two-year group	Four-year group		
	B	C	D	F	G	H	I	J	K	N	O	P	R	S	T	U	Ee	Ff	Cc	Jj	Kk	
(1)	8	9	6	2	4	8	8	4	3	7	4	—	4	2	3	5	10	11	10	8	10	126
(2)	6	9	5	2	8	7	8	1	3	4	3	—	4	—	3	4	6	9	6	4	7	99
(3)	—	—	—	—	—	1	—	—	—	1	1	—	—	—	1	—	1	—	—	—	—	5
(4)	—	1	1	—	—	—	—	—	—	3	—	—	—	—	—	—	4	—	2	—	—	11
(5)	—	—	2	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	2	—	—	4
(6)	—	—	2	—	—	1	1	1	—	2	2	1	—	—	—	—	1	—	1	—	2	14
(7)	—	—	—	—	1	—	1	—	—	—	—	—	—	—	—	—	—	1	2	—	1	6
(8)	—	—	—	—	—	1	—	1	—	—	—	—	2	3	1	1	2	—	1	—	—	12
(9)	—	1	1	—	1	2	1	1	—	3	2	—	2	3	1	1	2	—	—	—	—	21
(10)	—	—	—	—	—	1	—	—	—	1	3	4	2	2	—	1	2	—	—	—	—	16
(11)	1	—	5	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	1	—	—	7
(12)	1	—	—	—	1	3	—	2	2	1	—	—	—	—	1	—	1	—	—	1	1	14
(13)	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	1	—	1
(14)	—	3	3	—	3	1	1	3	1	—	5	—	3	2	—	3	3	2	1	2	1	37
(15)	—	1	—	—	—	—	—	—	—	—	—	—	—	—	1	—	—	—	—	3	—	5
(16)	4	5	4	—	5	4	5	1	—	1	4	—	3	2	7	4	4	7	4	—	3	67
(17)	4	5	—	—	5	4	5	1	—	1	4	—	3	2	7	4	4	7	4	—	3	63
(18)	4	5	—	—	5	4	5	1	—	1	4	—	3	2	7	4	4	7	4	—	3	63
(19)	—	—	—	—	2	1	2	—	—	—	—	—	—	—	—	—	—	—	—	—	—	5
(20)	1	1	1	2	1	2	3	7	1	4	3	1	5	2	3	1	3	3	3	2	3	52
(21)	—	—	—	1	—	—	1	3	3	4	—	—	3	1	2	2	2	2	—	1	2	27
(22)	4	2	5	—	—	—	—	—	—	1	—	2	1	—	—	1	3	—	3	—	—	22
(23)	—	—	—	—	—	—	—	—	—	2	—	—	—	2	—	—	1	—	—	—	—	5
(24)	5	2	2	6	1	6	4	6	7	2	—	—	2	3	5	3	3	7	4	5	3	76
(25)	—	—	—	1	2	—	2	—	—	—	—	5	—	—	—	—	—	1	—	—	—	11
(26)	—	—	—	—	3	—	3	1	1	—	—	—	2	—	3	1	3	3	—	—	—	20
(27)	2	3	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	5
(28)	1	—	—	—	—	—	—	—	—	1	2	—	—	—	—	1	—	2	—	—	—	7
(29)	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	1	—	—	1
(30)	—	4	2	—	1	—	—	—	—	3	2	—	2	—	—	—	—	—	1	—	1	16
(31)	2	2	—	—	—	1	1	—	2	3	2	—	—	—	—	—	—	—	1	—	—	14
(32)	—	—	—	—	—	—	—	—	—	1	1	—	—	—	1	1	—	—	—	—	—	4
(33)	4	—	—	—	—	1	1	—	—	1	—	1	—	—	1	1	—	2	—	—	2	14
(34)	—	—	—	—	—	1	1	—	1	1	—	—	1	—	—	—	1	—	—	—	—	6

first one, and would carry them back to his work table, one in each hand. Subjects C and D, in the two-year group, were observed on one occasion each to reach for a play object with the left hand, although the right hand was unoccupied. On each of these occasions the desired object was on a shelf placed at such a height that it was necessary for the child to stand on tiptoe. In one case, the object was at the extreme left, thus more readily accessible to the left hand. In the other case, the object was at the right; however, a projecting board at the right rendered the article more easily accessible to the left hand in reaching than to the right; and the right hand was used by the child as a means of steadying the body.

When the right hand was occupied, and something dropped to the floor, the left hand was used to pick up the object; unless the object was more readily accessible to the right hand, in which case the right hand usually relinquished what it held and secured the dropped object. When tools of manipulation such as the scissors, the paint brush, or crayon, were readily accessible to the left hand rather than the right they were picked up by the "convenient" left hand; however, they were invariably passed immediately to the "preferred" right hand for manipulation. When the right hand held something with which the child had been actively working, the left hand picked up other accessories. For example, one morning subject B was observed standing in a pen filled with blocks of wood, holding in his right hand a heavy hammer, while with his left hand he was picking up and throwing out blocks of wood. Still grasping the hammer in the right hand, he climbed over the side of the pen, supporting himself with the left hand, and hammered vigorously with the right hand on the boards he had thrown out. It was noted, however, that even though the right hand were occupied with one object, and another object was desired which was to be actively manipulated, the first object was usually released by the right hand which then picked up the second object. Thus, when going to the box of nails with the hammer held in the right hand, subject F picked up the nails with his unoccupied left hand. However, when getting the saw, although he was still holding in his right hand the hammer he had

been using, and although the left hand was unoccupied, subject F first put down the hammer and then picked up the saw with the right hand, actively manipulating it with that hand.

Serving milk to the children in the group was performed by one subject in the three-year group, subject H; and by two children in the four-year group, subjects N and O. Subject H carried the cups, one by one, by the rim with his right hand, and handed them to the children or placed the cups in front of the children, with the right hand. The method adopted by subjects N and O respectively was sometimes unimanual and sometimes bimanual. The hand used in the unimanual performance apparently depended upon the position of the handle; that is, when the cup was so placed on the tray that the handle was toward the right, the child grasped the handle by the right hand, and when it was turned toward the left, the child used the left hand. Usually, however, the unoccupied hand supported the side of the cup opposite the handle.

In the two-year age group, lifting a cup of milk to the mouth was a bimanual performance, according to the few occasions noted. Holding a cracker while eating it was a bimanual performance on two occasions, and unimanual on three occasions. The right hand was used when the performance was unimanual.

In the three-year age group and in the four-year age group, the method of manipulation employed with the cracker and cup of milk when eating, varied with different children, and sometimes on different days or during the same day with a given child. The following methods were noted:

(1) Holding the cracker in the right hand while eating the cracker; then placing it on the table in order to pick up the cup of milk with one hand. The right hand was always used when the manipulation of the cup was unimanual, and was usually held by the handle, though occasionally a subject held it by the side. The latter method was used when the handle was toward the left; however, it was usually followed by a bimanual method, in that the left hand would be used to support the handle.

(2) Holding the cracker in the right hand while eating; then placing it on the table in order to pick up the cup of milk with both hands, one hand holding the handle of the cup, while the other supported the side of

the cup. No consistency was noted in the function assumed by either hand, as the convenience of the situation apparently determined that factor. Thus, when the cup had been so placed before the child by the server that the handle was at the right, the right hand of the child held the handle while the left hand supported the side. When the cup had been so placed by the server that the handle was at the left, then the left hand held the handle while the right hand supported the side. On no occasion was the child observed to turn the cup so that the handle was at the side opposite to that at which it had been placed.

(3) Holding the cup by the handle with the right hand and holding the cracker in the left hand, alternately eating and drinking. This method was used by two of the four-year-olds. The cup had been so placed by the server that the handle was at the right.

(4) Holding the cracker in the right hand; then passing it to the left hand in order to pick up the cup with the right hand, and then alternately eating and drinking. This was noted on one occasion only, in the performance of one child.

(5) Holding the cracker in the right hand, and picking up the cup,—which was so placed that the handle was at the right—by the side with the left hand. This was noted on one occasion as one method used by Subject R during a short part of one period of observation.

Subjects C and D, two-year-olds, were each observed in the act of handing an object to another child. At the time of the observation, subject D was holding a piece of plasticine in each hand. Another child asked her for a bead which was on the table nearby. Subject D relinquished the piece of plasticine which was in her right hand, and reached for the bead and passed it to the second child with that hand. Subject C at the time of observation was holding a hammer in his right hand, when another child in the group dropped a bead, which rolled toward the right of C. C put down the hammer and picked up the bead with the right hand, passing it to the child with that hand.

In the four-year age group, one child, subject N, was observed in handing objects to others. He had picked up a book with the right hand, placing it under his right arm. He then picked up several others with the unoccupied left hand and placed them also under the right arm. He went around shouting "books for sale;" and distributed them to purchasers, passing them with the unoccupied left hand.

Wiping the table, floor, or blackboard, was noted in the performance of one or more subjects in each of the three age-groups. When both hands were unoccupied, all of the children observed used the right hand; however, when the right hand was occupied, there was some variation in individual performance. Subject D on the three occasions noted, put down the article which she held in her hand in order to secure the cloth and wipe up the water from the floor or table. Subject N, on one occasion, while holding in his right hand a piece of chalk with which he was drawing on the blackboard, reached with the left hand for the cloth and wiped out the drawing with the cloth held in that hand. Subject O, under the same condition, picked up the cloth with the right hand while holding the chalk in that hand, and wiped the drawing from the blackboard with both cloth and chalk in his right hand.

Pulling a wagon was performed by two subjects, G and I, on one occasion each. Subject I used the right hand during the short period in which he engaged in this activity. Subject G alternated in the use of the hands.

Drawing with chalk on the blackboard was observed in the performance of one subject in the three-year group and six subjects in the four-year group. This activity was invariably performed by all subjects with the right hand. When a crayon of a color different from the one in use was desired, sometimes the subject would first dispense with the piece he was holding and reach into the box or on the ledge for the new piece, with the right hand. Sometimes the subject would reach with his unoccupied left hand for the new piece, immediately releasing the first piece which he held in the right hand, and transferred the second piece to the right hand for manipulation.

The peg board was noted in the activities of the two-year-olds only. The two subjects observed, B and D, differed in type of manipulation, and in degree of bias for their "preferred" right hand. Subject D consistently used her right hand for both picking and placing the pegs regardless of the position of the box containing the pegs—that is, whether the box was at her right, at her left, or directly in front of her. In five periods of observation, during which a total of 100 pegs were placed, only 3 or 4

were placed by D with the left hand. Subject B, on the other hand, varied his manipulation in different trials, and also within the same trials. When the box of pegs was at his right, he picked and placed all but a few with the right hand, picking the remainder with the right hand, but placing them with the left. When the box of pegs was at his left, he picked all of the pegs from the box with the left hand and passed them to the right hand to place in the peg board.

Block building was observed in all three age-groups, although it occurred more frequently in the three-year group than in either the two-year or the four-year group. During the course of a single observation, the method of manipulation was sometimes unimanual, one hand picking and placing the blocks, and at other times bimanual, one hand picking the blocks and the other hand placing them. Manual choice in block building seems to be influenced by various factors, such as, the location of the blocks with reference to the child, and the direction in which the child is building. The direction in which the child is building appears to be influential under conditions when extreme right or left is involved. When the blocks were at the right of the subject, the right hand was almost invariably used to pick the blocks, and usually used to place them; however, when the child was building toward the left, the blocks were frequently passed from the right hand to the left hand for placement, particularly those which were designed for the extreme left of the building or railroad track under construction. When the blocks were at the left of the child, the tendency on the part of the majority of the children observed was to pick them with the left hand and pass them to the right hand for placing, unless the direction of building was toward the extreme left, when the left hand also placed the blocks. There was some variation with respect to the blocks lying at the left. For example, subject K would use the right hand to pick and place the blocks, regardless of whether they were lying at his right or at his left, except that in placing the blocks at the extreme left of the structure erected he would use the left hand. Subject J, on the other hand, would use the right hand to pick and place the blocks lying at his right, and would use the left hand to pick and place those lying at

his left, except when building to the extreme right or extreme left, when the "convenient" hand would be used to do the placing. When the blocks were at the front of the child, the usual method was to alternately pick and place a few with the right hand, then a few with the left, apparently showing no definite preference for either hand.

II. Bimanual-1 acts. In activities such as drawing with crayon on paper; writing; painting; brushing over cubes of paint; swirling a brush about in a jar of water; stamping numbers on paper with a rubber stamp; cutting out pictures, numbers, or designs, with a pair of scissors; brushing over cut-outs with a paste brush, and fastening them to a cardboard or other background; manipulating plasticine as an object worked upon by another tool; sandpapering blocks or other wooden objects; manipulating implements, such as a saw, hammer, chisel, vise, screw driver: in all of these activities in which the hands coöperate simultaneously to effect the completion of a total situation, and in which the function of the two hands is different in kind and degree, the right hand was invariably used by all of the children in all three age-groups for the active, major part of the performance, and the left hand was invariably used for the relatively passive, accessory function. Thus, the right hand was consistently used to manipulate the crayon, the pencil, the paint brush, as the left hand rested on the paper, held the object which was being colored, supported the jar of water as the brush was being swirled about in it, or held the cube of paint on the table as the brush was passed over it. The right hand was used to manipulate the rubber stamp as the left hand held the stamp pad, or rested on the paper upon which the numbers or letters were pressed; the right hand manipulate the scissors as the left hand held the paper; cut slices off the ball of plasticine with a tiny board as the left hand held the plasticine down on the work table; brushed over cut-outs with the paste brush as the left hand held the cut-out steady to prevent slipping; manipulated the sandpaper as the left hand held the blocks or supported the side of a box which was being smoothed; wielded the hammer, saw, chisel, vise, screw driver, as the left hand supported the board which was being sawed or pried apart, or held the nail which was

being driven into the board. Occasionally subjects J and K would use both hands simultaneously for a short time in hammering. Subject J held the right hand at the top of the handle and the left hand down near the hammer, whereas subject I held the hands in reverse fashion. The chisel and small screw driver were used occasionally, not as tools with which active work was performed, but as objects on which activity was exerted. For example, subject F one day held the chisel against a board and hammered down upon the chisel in an endeavor to split the board. The screw driver was used in the same way by subject G. Under these conditions, the chisel or screw driver was held down on the table or board by the left hand, as the right hand wielded the hammer upon it.

Subjects G, F and I in the three-year group, and subject P in the four-year group were observed while picking little pins with celluloid tops of different colors from tiny boards, and sticking the pins into a beaver board. Subjects G and P each consistently used the right hand in picking the pins from the tiny boards and in sticking them into the beaver board, regardless of the position of the box which contained the tiny boards. When the box containing the boards was at the left of either of these subjects, he would take a board from the box with the left hand and hold it in that hand as he picked the pins from it and placed them with the right hand; and when the box was at the right, each of these subjects would pick the board from the box with the right hand, and pass it to the left hand to hold, as the right hand did the active manipulating. Subject F, in the one performance noted of this activity, would reach over with his right hand and take a tiny board from the box, which was at his left; and, holding it in the right hand, he would remove the pins from it and stick them in the beaver board with the left hand. Subject I, with the box of boards in front of him, would take up a board with the left hand, and while holding it in that hand, would remove the pins therefrom and place them in the beaver board with the right hand. After a short while he would reverse the procedure, taking up the board from the box with the right hand, and while holding it in that hand, remove the pins and place them in the beaver board

with the left hand. Thus it appears that individual variation was shown in this activity.

Four three-year-olds and three four-year-olds were observed on one or more occasions in carrying a painting or drawing which they had completed, from their work table to the display wall, and pinning it to the burlap stretched on the wall for that purpose. Sometimes a subject would pick the picture up from the table with the right hand, after laying down the paint brush or crayon which he had been manipulating with that hand, and would carry the picture to the wall in the right hand. Then the picture would be transferred to the left hand and held against the burlap with that hand, as the subject reached for a pin with the right hand and pinned the picture to the burlap with the right hand. Sometimes a subject would pick the picture up from the table with the unoccupied left hand before laying down the paint brush or crayon which he had been using with the right hand, and would carry the picture to the wall with the left hand. Under this latter condition, all of the subjects observed with the exception of subject I would then hold the picture against the burlap with the left hand, and reach for the pin with the right hand, and pin the picture to the burlap with the right hand. Subject I, however, on two occasions carried the painting to the burlap with the left hand, then transferred it to the right hand to hold against the wall, as he reached for the pin with the left hand and endeavored to pin the paper to the burlap with that hand. Failing in the attempt, he transferred the paper again to the left hand to hold against the burlap as he pinned it with the right hand. On the third occasion, he immediately held the paper against the wall with the left hand as he reached for the pin with the right hand and pinned the paper to the burlap with that hand. In the fourteen observations recorded of this activity, success was finally achieved in all cases by holding the paper against the burlap with the left hand, and pinning it thereto with the pin held in the right hand. While reaching for the pin was a task which could apparently be achieved by either hand, pinning the paper to the wall seemed to call for the use of the right hand.

Peg board activity and playing with blocks were treated in the

section dealing with unimanual activities, as the method of manipulation in each of these varied from unimanual to bimanual within the performance of a given individual in the same period of observation. Stringing beads was not performed by any of the subjects in the right-handed group.

III. Bimanual-2 acts. In carrying objects such as a jar of water or a cup of milk, a subject would occasionally use both hands, each hand supporting a side of the jar or the cup. Sometimes the handle of the cup would be held by one hand and the side of the cup would be supported by the other. In all cases observed, the hand which held the handle of the cup was the one conveniently located with reference to the handle. On no occasion was a child observed, while carrying a cup of milk or conveying it to the mouth, to turn the handle of the cup around so that it might be held by the preferred hand.

Moulding of plasticine was noted in all three groups. The two-year-olds favored primarily the bimanual-1 method, in which the plasticine was held on the table by the left hand, while the right hand cut slices from the ball of plasticine with a tiny stick, or dug holes in it with the stick. The three-year-olds and four-year-olds occasionally manipulated the plasticine in this manner, however they favored the bimanual-2 method of moulding the plasticine, in which both hands participated in the kneading and forming. Preferential use of either hand in degree of functioning was not observed.

Sweeping was performed by 3 subjects in the three-year group and by 2 in the four-year group. Each of these children held the right hand at the top of the broom handle, and the left hand about half way down the handle.

Left-handed subjects

I. Unimanual acts. In unimanual acts such as picking up objects which had fallen, and picking up and carrying objects required in manipulation, the two left-handed subjects showed some difference in performance. Ff was nearer the right-handed children in that she frequently used the right hand to pick up objects which were equally accessible to either hand, and when neither

hand was occupied. In securing objects from the supply table for use at her own work table, she usually picked up one with the left hand, then a second object with the right hand. On the one occasion when she was observed pulling a little cart, she held the string first by the right hand, then by the left hand. These were the only unimanual activities in which Ff participated.

Subject Ee decidedly favored the left hand in picking up objects which had fallen, carrying supplies to his work table, wiping up spilt water from the table with a cloth, regardless of whether the left hand were occupied or not. In carrying objects to his work table, he usually carried one at a time, using the left hand, although he occasionally carried one in each hand.

When serving milk to the children in his group, subject Ee picked up and carried each cup by the left hand, sometimes by the handle, sometimes by the side, unsupported by the right hand. In picking up the cups from the table at which the children had been eating, he used the left hand exclusively; however, when a child passed him the cup with the right hand, he would accept with his right hand and carry the cup back in that hand.

Subject Ee was observed during two lunch periods. He would hold the cup in one hand and the cracker in the other hand, occasionally changing hands, so that the hand which had been holding the cracker held the cup, and the hand which had been holding the cup now held the cracker. He did not, on any occasion noted, turn the cup around so that the position of the handle would be changed.

On the two occasions when Ee drew on the blackboard, he used the left hand exclusively.

Block building, as in the case of the right-handed children, was sometimes unimanual and sometimes bimanual. When unimanual, the left hand predominated in use. When bimanual in nature, the function of the hands was determined, as in the right-handed group, by factors of convenience, such as the direction of building.

II. Bimanual-1 acts. In activities such as drawing with crayon on paper; painting; brushing over cubes of paint; swirling a brush about in a jar of water; cutting out pictures, numbers,

or designs, with scissors; brushing over cut-outs with a paste brush, and fastening them to a cardboard or other background; manipulating plasticine as an object worked upon by a tool; sandpapering blocks or other wooden objects; manipulating implements, such as a saw, hammer, chisel, vise, screw driver: in all of these activities in which the function of the two hands is different in kind and degree, the left hand was invariably used for the active, major function, while the right hand was used for the relatively passive, accessory rôle. On one occasion only did subject Ee use the right hand for the active, major rôle, while the left hand performed the minor rôle; and that was in the use of a saw, when the board had been clamped on to the bench by the Director of the Institute in such a way that the use of the saw with the right hand was the only possible method. Ee used the saw with the right hand for a while, then used both hands simultaneously.

Ee and Ff were each observed on several occasions while pinning a picture to the burlap. Each of these subjects on one occasion, after having carried a painting from the work table to the wall with the left hand, held the picture against the burlap with the left hand, and after securing a pin with the right hand, attempted to pin the picture to the burlap with the right hand. Failing in the attempt, the subject transferred the pin to the left hand and the paper to the right hand and succeeded in pinning the paper to the burlap with the left hand. On all other occasions, however, each of these subjects held the paper against the burlap with the right hand, regardless of which hand had carried it over, and reached for the pin and fastened the paper to the burlap with the left hand.

Playing with blocks was noted in the unimanual section, as the method used in this activity varied from unimanual to bimanual in the performance of a single period. Writing, stamping numbers on paper with a rubber stamp, placing pins in a beaver board, pegging, and stringing beads were not noted in the periods of observations of either of these subjects.

III. Bimanual-2 acts. Carrying objects, lifting a cup of milk to the mouth, and serving milk, have been noted in preceding sections. As these acts were, within the course of a single obser-

vation, sometimes performed as unimanual and sometimes as bimanual activities, it is more convenient to treat them together.

Plasticine was kneaded and moulded and rolled by both hands functioning coöperatively.

Sweeping was performed by subject Ee only. Contrary to the manipulation of the right-handed children, this subject held the left hand at the top of the handle, and the right hand half way down the handle.

Ambidextrous group

1. Unimanual acts. In the performance of unimanual acts such as picking up objects and carrying objects, when both hands were unoccupied and the object to be grasped was equally accessible to both hands, none of the subjects used a given hand exclusively. Some variation in preferential usage, however, was shown, as subjects Cc and Kk each used the left hand more frequently and subject Jj used the right hand more frequently, under these conditions. When, however, convenience was a factor, manual choice was affected accordingly. If the right hand were occupied, the left hand was usually used to secure a desired object; or, if the desired object were nearer one hand than the other, the convenient hand was used.

Subjects Cc and Kk were each observed in picking up a cloth and wiping the floor. The hand favored by the convenience of the situation was the hand used by each of these subjects in one performance of this activity. Thus, Cc picked up the cloth, which was lying to the right of her, with the right hand and manipulated it with that hand for a while. In accordance with her usual custom, she soon transferred it to the left hand for a short time, then back to the right hand again. Subject Jj, while holding a paint brush in the right hand, secured the cloth with the unoccupied left hand and wiped the floor. On a second occasion, although both hands were unoccupied, he picked up the cloth with the left hand and manipulated it. On both of these occasions, however, he soon transferred the cloth to the right hand for action; then later back to the left hand again.

Subjects Cc and Kk were each observed during one period in

pulling a little wagon. Each subject held the string first in the left hand, then transferred it to the right hand.

While pulling the little wagon by the string which she held in her left hand, Cc "sold" the director of her section a block of wood, holding out her unoccupied right hand to receive the bit of paper which passed for money, before delivering her wares. Grasping the money in her right hand, she dropped the string which she held in the left hand, and picked up a block of wood from her cart and handed it to the director with the left hand. During another period of observation, Cc picked up a box of beads with her left hand, and with the unoccupied right hand picked the beads out of the box one by one and handed them to the rest of the group. The hand used in handing objects to others was apparently determined by the convenience of the situatuion.

Cc alternated in the use of her hands, not only in pulling a wagon, and in wiping the table and floor, but also in picking up and conveying to her mouth the pieces of cracker which she had crumbled with her left hand while holding it in her right hand, and in picking and placing pegs during a period of unimanual operation. But one observation was made of Cc in holding a cup of milk. The cup had been so placed by the director that the handle was at C's right. She picked up the cup by the handle with the right hand, occasionally supporting the side with the left hand.

Subjects Jj and Kk were each observed during one period in building blocks. The performance of each of these subjects was unimanual in type, and ambidextrous. That is, one hand would both pick and place the blocks; however, the hands were used alternately. Convenience apparently operated to some extent in determining the favored hand.

Subject Jj threw a rubber ball through a steel hoop into a cloth bag fifteen times in succession on one occasion, using his right hand in all throws, although he was informed by the observer that he might use either hand. He seemed to derive great joy in the activity, and stated that he often played ball with his father.

II. Bimanual-1 acts. The three subjects in this group differed

considerably from each other in the performance of bimanual-1 acts observed during the course of this study. The two-year old, subject Cc, and one of the four-year olds, subject Kk, were nearer each other in type of manipulation than were either of them to subject Jj. Both Cc and Kk used the hands interchangeably for the major part of such activities as drawing with crayon on paper, painting, brushing over cubes of paint, swirling a brush about in a jar of water, cutting out pictures or designs with a pair of scissors, manipulating plasticine as an object worked upon by a tool, manipulating the hammer. Each of these two subjects favored first one hand, then the other, with the major or active part of these activities, the hand not so favored at a given time performing the relatively passive but accessory part of the total act. These two subjects differed, however, in that Kk apparently favored neither hand more than the other in any of the activities noted, whereas Cc favored the right hand to a greater extent than the left in performing the active rôle in drawing, cutting pieces of plasticine off of the ball with the little wooden slab, and in manipulating the scissors; and favored the left hand primarily in the active rôle in hammering.

Subject Jj alternated in the use of his hands for the major part of such activities as drawing and writing his name. The hand used in the major part of these activities was not apparently determined by the hand with which he picked up the tool. Sometimes he would pick up the pencil with the left hand and write or draw with that hand for a while, then transfer the pencil to the right hand for manipulation. Again, he would pick up the crayon or the pencil with the right hand—particularly if it were more accessible to that hand—and transfer it to the left hand for manipulation; shortly thereafter passing it to the right hand for use. Throughout a single observation he would alternate several times in the use of the hands. In drawing circles, Jj moved the pencil counter-clockwise, regardless of which hand was performing. In writing, Jj wrote both the normal left to right and the reversed direction, right to left, and used both methods with either hand. His letters, when written in the reversed direction, were likewise reversed. Two observations were made of his writing, the obser-

vations being about a week apart. His first name was written four times, and his last name twice. The first name was written three times by the left hand, in reversed letters, from right to left. The fourth time, the left hand started to write the first name in normal fashion, from left to right, but when half through, the pencil was transferred to the right hand for completion of the task. During one observation the last name was written in reversed fashion, from right to left, the right hand starting the performance, but when half the letters were formed, the left hand took over the task and completed it. On another occasion, Jj started to write his last name in reversed fashion with the left hand, and when half way through, put down his pencil, stating that he did not know what came next. The observer wrote his name in full with the pencil held in her right hand, writing in normal left to right fashion. He again picked up the pencil with the left hand and copied from her sample, writing, however, in reversed fashion.

In the use of the vise, also, Jj sometimes alternated in the use of the hands, first using the right hand for the major part of the performance and the left hand for the accessory rôle; then reversing the hands. However, in hammering, sawing, and in the use of the scissors and paste brush, the right hand was used exclusively for the major function, the left hand performing the accessory role. This method was followed regardless of which hand picked up the tool with which the activity was to be performed. Thus, once or twice the hammer was picked up by the left hand, and a nail by the right hand. The nail was transferred to the left hand and held down on the board, as the hammer was transferred to the right hand for active use.

Although subject Kk was six months older than subject Jj, he was far inferior to Jj in extent and quality of manipulation, as well as in general intelligence. While a greater variety of activities is listed for subject Kk than for subject Jj, the latter was by far the more active of the two. He would persist longer in a given activity, and focus his attention upon it, thereby accomplishing something. He was particularly fond of writing and of drawing. Kk, on the other hand, spent the major part of his time listlessly watching other children, wandering from one activity to another, and being relatively inactive most of the time.

Summary. A series of daily observations made on a group of pre-school children for the purpose of ascertaining the preferential use of the hands in daily uncontrolled activities, and of determining the consistency of such manual preference in repeated performances of any given activity, indicated the following facts:

Comparatively few of the types of activities observed were invariably unimanual in nature. Some of the activities observed were at times unimanual and at times bimanual in nature. The bimanual method of manipulation assumed two forms, in one of which the function of the two hands was the same in kind, and in the other, the function of the two hands differed in kind. The majority of the acts performed were of this latter type, in which one hand performed a major function, and the other hand aided in the performance of a relatively minor, accessory rôle.

There are certain activities which seem to lend themselves to a consistently preferential manipulation, activities in which it is preferable to cultivate efficiency by automatic action; whereas there are other activities in which the use of either hand can frequently be adopted, activities of such a nature that the situation itself determines which hand will be used. This differentiation is apparently made at a very early age; in fact, it was apparent in the performance of the four children below the age of three years who were observed in this study.

Thus, a consistency of manual choice was shown by all of the children observed, except three ambidextrous subjects, in the performance of one strictly unimanual act, namely, drawing with chalk on the blackboard, and in the major part of many so-called bimanual acts. In drawing with a crayon on paper, in writing, painting, brushing over cubes of paint, cutting out pictures with scissors, sandpapering blocks, manipulating implements such as a saw, hammer, chisel—in all of these activities, the children who had been termed right-handed by their parents invariably used the right hand for the active, major part of these performances, giving to the left hand the minor rôle. The children who had been designated left-handed by their parents invariably favored the left hand for the active, major part of these performances, using the right hand as an aid in the performance of the

minor, accessory function in the total situation. Only in the performances of the three children who, according to the report of their parents, were ambidextrous, was variation in the function of the two hands shown in these activities. These three children at times favored the right hand with the major rôle, and at times favored the left hand with that rôle. Varying degrees of ambidexterity were noted in the performances of these three children, however, as two of the subjects used the hands interchangeably in all activities, while one subject used the hands interchangeably for the major rôle in writing and drawing, but in other activities he approximated the performance of the right-handed children.

A certain degree of variability in manual choice was shown in the performance of practically all of the children in such unimanual acts as picking up objects, carrying objects, passing objects to others, wiping the floor or blackboard, pulling a wagon, block building, and placing pegs in a peg board. The factor of convenience apparently determined, to some extent, the hand used in these activities. Thus, in reaching for and picking up objects equally accessible to either hand, when both hands were unoccupied the children termed right-handers by their parents almost invariably used the right hand, and those termed left-handers almost invariably favored their left hand. However, when the "preferred" hand was occupied, or when the desired object was more conveniently located with reference to the non-preferred hand, the hand thus favored by circumstance was usually favored by the child.

General Summary

Convenience apparently plays an important rôle in the preferential manipulation of pre-school children in activities of certain types. In picking up and placing objects, in such activities as the marble board and the form board, when the objects of manipulation were equally accessible to either hand, a pronounced tendency was shown by the subjects in both the Right-handed and Left-handed groups, to use the hand preferred in daily activities, termed the "preferred" hand. When these objects were con-

veniently located with reference to the "preferred" hand, this tendency toward the use of the "preferred" hand was pronounced to an even greater extent, its use being practically exclusive by the subjects in both groups. When, however, the objects of manipulation were so located as to offer a convenience to the use of the "non-preferred" hand, but an inconvenience to the use of the "preferred" hand, considerable variability in degree of bias for the "preferred" hand was manifested by the subjects in both handedness groups.

These same tendencies were noted on the part of the children in both groups in an activity which involved running from a starting point to a desired object, and reaching for and grasping that object, under conditions calling for rapid, spontaneous choice of hand. The tendency toward the use of the "preferred" hand was pronounced on the part of the majority of the children in both handedness groups in this activity. Analysis of position assumed by the subject with reference to the desired object, after running from the starting point to that object, indicated that the factor of convenience seemed to operate here also. Thus, when the position assumed was on the side corresponding to the "preferred" hand, a pronounced tendency toward the use of that hand was noted in both handedness groups. When the position assumed by the subject was center, thus rendering the object equally accessible to either hand, there was likewise a tendency toward the use of the "preferred" hand in both groups, although in the Right-handed group this tendency was not as marked as when the position assumed was at the side corresponding to the "preferred" hand. When the position assumed by the subject was at the side opposite to that of the "preferred" hand, thus rendering the object of manipulation more accessible to the "non-preferred" hand, there was considerable variation in extent of preference for the habitually "preferred" hand in both handedness groups, some children favoring the "preferred" hand primarily, some showing marked favor for the "non-preferred" but convenient hand, and some showing no marked preference for either hand.

In situations where two desired objects of the same type, placed

in proximity to each other, were to be secured under conditions calling for rapid, spontaneous choice of hand, the young child showed no specialization in the use of the hands, using one hand to reach for the object and the other to hold it, nor did it favor either hand to any extent in point of time; but the hands functioned in the most efficient, convenient manner under the circumstance, as the method of manipulation primarily employed was that of reaching for and grasping an object with each hand simultaneously.

No consistent relation was shown between position assumed by the subject with reference to a desired object after running from the starting point, and manual "types," that is, the habitually right-handed or left-handed child. Relatively few of the subjects in either of the handedness groups assumed a given position in all trials, when running from the starting point to the basket containing the objects to be seized. However, when a single object was the stimulus, the majority of the subjects in the Right-handed group showed a marked preference for the position to the right of the object, while the subjects in the Left-handed group favored primarily the center position.

An inverse relationship was evident in the performance of all subjects between the position assumed with respect to the object seized, and direction of orientation by the subject after the desired object had been secured. When the position assumed was at the right, the direction of turn was practically invariably toward the left; and when the position assumed was at the left, the direction of turn was almost invariably toward the right.

No consistent relation was shown between direction of orientation by the subject after the desired object had been secured, and manual choice; nor was any consistent relation evident between direction of orientation and manual "types."

While none of the children in either the Right-handed or the Left-handed group used the "preferred" hand exclusively in all trials of the three tests in preferential manipulation given them, the majority of the children in both groups showed a strong bias for their "preferred" hand in all tests except in that section of the form board test in which an inconvenience was imposed on the use

of the "preferred" hand. There was some individual variation, however, in that a few children in each group used their "preferred" hand primarily under all conditions, even when an inconvenience was imposed upon its use; and a few children showed no preference for their habitually "preferred" hand in a test or portion of a test in which inconvenience to the use of that hand was not involved. Thus, the results of these various tests of handedness seem to indicate the existence of "degrees" of manual bias, ranging from a pronounced preference for either the right hand or the left hand, to a relatively ambidextrous state in which neither hand is definitely favored, or in which the hand "convenient" under the circumstance is favored. The two manual types designated conventionally as "right-handed" and "left-handed' apparently indicate "trends" rather than two distinct classes, at least in so far as activities of the type used in these tests are concerned. Since factors of convenience apparently predispose to the use of the "convenient" hand—practically exclusively when the convenient hand is also the habitually preferred hand, and to varying extent when the convenient hand is the non-preferred hand—it might be that the nature of manual choice under conditions offering equal opportunity for the use of either hand, as in the marble board test, is diagnostically more significant in ascertaining these "trends" than is the nature of choice when objects are conveniently located with reference to one hand but inconveniently located with reference to the other. A test of the type of the form board, given under conditions obtaining in this study wherein a convenience was offered to the use of the "preferred' hand in the manipulation of the forms lying on one side of the board, but an inconvenience was offered to that hand in the manipulation of the forms lying on the other side of the board, seems to provide a method of ascertaining the "degree" of manual bias. An activity such as the picking-up-toy test, in which the subject runs from the starting point to the desired object, thus permitting the occurrence of a variety of fluctuating environmental conditions which may operate to influence manual choice, does not seem as adequate a means of ascertaining either the "trends" or the "degrees" of preferential handedness as do the

marble board and the form board respectively, in which these environmental conditions are controlled.

Improvement in speed of performance by the "non-preferred" hand in a practice series in pegging was shown by a group of right-handed children, ranging in age from 3 years to 5 years. Improvement was also noted in this group in the performance of the unpracticed right hand after the practice series by the "non-preferred" left hand, as compared with the performance of the right hand prior to the practice series, suggestive of transfer of training. The performances of the majority of the children in the left-handed group did not show a marked tendency toward improvement in either the practiced right hand or the unpracticed left hand, although there was some individual variation. Many factors were noted which render difficult a study of learning in children through speed of performance.

Training of strongly left-handed children of pre-school age in the use of the right hand in motor activities involving gross muscle coördination as well as those involving the finer muscle coördinations, seems possible. Individual differences were noted with respect to the following: (1) extent of learning as measured by accuracy of performance, (2) attitude of the subject toward the use of the "non-preferred" right hand, and (3) presence of observable tension in the relatively unoccupied left hand and in the face of the subject. This tension existed during the early part of the test series, and was noted to gradually decrease, and apparently disappeared completely after a few days of testing. Improvement was manifested earlier in the test involving primarily the gross motor coördinations, than in the test involving the finer motor coördinations.

Daily observations of the preferential use of the hands by children of pre-school age in activities of their own choice indicated the following significant facts:

(1) Comparatively few of the types of activities performed were invariably unimanual in nature. The majority of the acts were bimanual, of the type in which one hand performs a major function, and the other hand aids by the performance of a relatively minor, accessory rôle.

(2) There are certain activities which seem to lend themselves to a consistent preferential manipulation, activities in which it is preferable to cultivate efficiency by automatic action; whereas there are other activities in which the use of either hand can frequently be adopted, activities of such a nature that the situation itself determines which hand will be used. This differentiation is apparently made at a very early age; in fact, it was apparent in the performance of the four children ranging in age between 2 years 4 months and 2 years 9 months, who were observed in this study.

Thus, a consistency of manual choice was shown by all of the children observed in this study, except three ambidextrous subjects, in the performance of one strictly unimanual act, namely, drawing with chalk on the blackboard, and in the major part of many so-called bimanual acts. In drawing with a crayon on paper, in writing, painting, brushing over cubes of paint, cutting out pictures with a scissors, sandpapering blocks, manipulating implements such as a saw, hammer, chisel—in all of these activities, the children who had been termed right-handed by their parents invariably used the right hand for the active, major part of these performances, giving to the left hand the minor rôle; whereas the children who had been designated left-handed by their parents invariably favored the left hand for the active, major part of these performances, using the right hand as an aid in the performance of the minor, accessory function in the total situation. Only in the performances of the three children who, according to the report of their parents, were ambidextrous was variation in the function of a given hand shown in these activities, the right hand performing the major function at times, the left hand performing that rôle at other times.

On the other hand, a certain degree of variability in manual choice was shown in the performance of practically all of the children in such unimanual acts as picking up objects, carrying objects, passing objects to others, wiping the floor or blackboard, pulling a wagon by a cord, block building, and placing pegs in a peg board. The factor of convenience apparently determined, to some extent, the hand used in these activities.

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VITA

Julia Heil Heinlein (nee Julia Elizabeth Heil) was born in Baltimore, Maryland, on October the eighth, 1895. She received her elementary and secondary school education in the public schools of Baltimore City, graduating from the Eastern High School in 1912. She later pursued courses of study in the College for Teachers at the Johns Hopkins University, from which institution she received the degree of Bachelor of Science in June, 1925. In the fall of 1925 she enrolled as graduate student in the Department of Psychology. For the year 1926–27, she was appointed student-assistant in the Department. For the year 1927–28, the National Research Council appointed her Fellow in Child Study, the experimental phases of her research being conducted in the Child's Institute of the Psychology Department of the Johns Hopkins University. In February, 1928, she received the degree of Master of Arts in Psychology from the Johns Hopkins University.